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***Restorative treatment practices  
and dentist-related factors***

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ACADEMIC DISSERTATION

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“Where is the wisdom we have lost in knowledge?  
Where is the knowledge we have lost in information?”  
T.S. Eliot

## ABBREVIATIONS

AAPD	American Academy of Pediatric Dentistry
ADA	American Dental Association
ANOVA	Analysis of variance
ART	Atraumatic restorative treatment
Bis-GMA	Bisphenol A glycidyl methacrylate
CCT	Controlled Clinical Trial
CDO	Chief Dental Officer
CI	Confidence interval
CL50	Clinical longevity
DMF or DMFT	Number of decayed, missing, filled teeth
DMFS	Number of decayed, missing, filled surfaces
DO	Disto-occlusal
EU	European Union
FDI	World Dental Federation
FiMnet	Finnish Medical Network
GA	General anesthesia
GDP	General Dental Practitioner
GDS	General Dental Services (UK)
GI	Glass-ionomer
GIs	Glass-ionomer and its derivatives
KELA	Social Insurance Institution (FIN)
LA	Local anesthesia
MO	Mesio-occlusal
MOD	Mesio-occlusal-distal
NHS	National Health Service (UK)
NIOM	Scandinavian Institute of Dental Materials
OR	Odds ratio
PBS	Practice-Based Studies
PDS	Public Dental Service
RCT	Randomized Controlled Trial
SD	Standard deviations
TEGDMA	Triethylene glycol dimethacrylate
USPHS	United States Public Health Service

## ABSTRACT

**Palotie U.** *Restorative treatment practices and dentist-related factors.*

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This study aimed at elucidating real-life aspects of restorative treatment practices. In addition, dentists' views and perceptions of and variation in restorative treatment practices with respect to dentist-related factors were evaluated. Reasons for placement and replacement of restoration, material selection, posterior restoration longevity, and the use of local anesthesia were assessed on two cross-sectional data sets. Data from the Helsinki Public Dental Service (PDS) included details on 3057 restorations performed by dentists ( $n=134$ ) during routine clinical work in 2001. The other PDS data from Vantaa were based on 205 patient records of young adults containing information on 1969 restorations investigated retrospectively from 1994-1996 backwards; 51 dentists performed the restorations. In addition, dentists' self-reported use of local anesthesia and estimates of restoration longevity were investigated by means of a nationwide questionnaire sent to 592 general dental practitioners selected by systematic sampling from the membership list of the Finnish Dental Association in 2004. All data sets included some background information on dentists such as gender, year of birth or graduation, and working sector. In PDS in 2001, primary caries was the reason for placement of restoration more often among patients aged under 19 years than among older patients ( $p<0.001$ ). Among patients over 36 years of age, replacements represented the majority. Regarding dentist-related factors, replacements of restorations were made by younger dentists more frequently than by older dentists ( $p<0.001$ ). In PDS in 1994-1996, the replacement rate of posterior restorations was greater among female dentists than among male dentists ( $p=0.01$ ), especially for amalgams ( $p=0.008$ ). The mean age of replaced posterior restoration among young adults was 8.9 (SD 5.2) years for amalgam and 2.4 (SD 1.4) years for tooth-colored restorations, the actual replacement rate for all existing posterior restorations being 7% in PDS in 1994-1996. Of all restorative materials used, a clear majority (69%) were composites in PDS in 2001. Local anesthesia was used in 48% of cases and more frequently for older patients (55%) than for patients aged under 13 years (35%) ( $p<0.001$ ). Younger dentists more often used local anesthesia for primary restoration than did the older dentists ( $p<0.001$ ), especially for primary teeth ( $p=0.005$ ). Working sector had an impact on dentists' self-reported use of local anesthesia and estimates of restoration longevity; public sector dentists reported using local anesthesia more frequently than private sector dentists for Class II ( $p=0.04$ ) and for Class III restorations ( $p=0.01$ ). Private sector dentists gave longer estimates of posterior composite longevity than public sector dentists ( $p=0.001$ ). In conclusion, restorative treatment practices seem to vary according to patient age and also dentist-related factors. Replacements of restorations are common for adults. For children, clear underuse of local anesthesia prevails.

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## LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following original articles, which are referred to in the text by their Roman numerals. In addition, some unpublished data are presented.

I Palotie U and Vehkalahti M. Restorative treatment and use of local anesthesia in free and subsidized public dental services in Helsinki, Finland. *Acta Odontologica Scandinavica* 2003; 61: 252-256.

II Palotie U and Vehkalahti M. Reasons for replacement and the age of failed restorations in posterior teeth of young Finnish adults. *Acta Odontologica Scandinavica* 2002; 60: 325-329.

III Palotie U and Vehkalahti MM. Use of local anesthesia in restorative treatment for adults in Finland. *Acta Odontologica Scandinavica* 2007; 65: 129-133.

IV Palotie U and Vehkalahti MM. Finnish dentists' perceptions of the longevity of direct dental restorations. *Acta Odontologica Scandinavica* 2009; 67: 44-49.

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# 1 INTRODUCTION

Caries is a chronic infectious disease with no systematic medicine or vaccine for a cure. However, vast advancements have occurred over the past 25 years in methods to interfere with the caries process. Caries disease is responsive to preventive approaches, such as daily plaque removal and use of topical fluorides and xylitol, leading to arrest of caries lesion progression. Nevertheless, a lesion already involving infected dentin needs restorative action with a technique that preferably maintains pulp vitality. The goal should be restoring tooth form, function, and esthetics with appropriate materials. Undergraduate dental education of caries management continues to teach techniques for restorations.

Over the past 25 years, caries among children and adults has been in continuous decline in Finland (Nordblad et al., 2004, Suominen-Taipale et al., 2008) as well as elsewhere in Europe (Marthaler, 2004). In Finland, recent investigations on restorative treatment for children are sparse due to low caries incidence; in 2003, DMFT was 1.2 among 12-year-olds (Suominen-Taipale et al., 2009). On average children aged 6-18 years had 0.7 restorations per child treated at the Public Dental Service (PDS) in 2000, and overall the number of restorations performed for children aged under 18 years was half of that in 1985 (Nordblad et al., 2004). In Finnish adults in 2000, the average number of filled teeth was 12.4 and the number of decayed teeth was 0.8 compared with 2.5 in 1980 (Suominen-Taipale et al., 2008). For adults, restorative procedures represent nearly half of all dental procedures (Läärä et al., 2000, Helminen, 2004a, 2004b). Moreover, people today are expected to live and retain their teeth longer, generating a variety of dental problems, such as root caries, among no longer edentulous elderly persons. In the future, esthetic demands of modern society, erosion due to new dietary habits and abrasion due to stressful work will all benefit from dental restorations.

Replacement of restoration affects patients' well-being, dentists' workload, and costs of treatment (Tobi et al., 1999, Sjögren and Halling, 2002a, 2002b). From an economic point of view, even a minor increase in restoration longevity would reduce dental expenditures, which are continuously rising (Brown and Lazar, 1998), along with other medical costs. The worst scenario leads to a cycle of re-restorations, previously described as the tooth death spiral (Elderton, 2003). The present controversial knowledge of factors affecting restoration longevity suggests a substantial contribution by dentists. Variation in dentists' diagnoses and restorative treatment plans proposed for the same patient is a well-known phenomenon (Rytömaa et al., 1979, Shugars and Bader, 1992). One modern way to try to render treatment practices similar is the evidence-based "Best Practice" guidelines, which have already been published nationally e.g. in Sweden and Scotland. Such a guideline for caries management concentrating on caries prevention and early diagnosis has recently been issued in Finland as well. However, change in clinical behavior does not automatically ensue; on the contrary, some dentists might even perceive these guidelines as a threat to their clinical autonomy and be reluctant to comply with them (Baelum, 2008).

The great majority of patients value relatively painless treatments. However, dental pain management with the aid of local anesthesia can be distressing for patients as well as for dentists (Dower et al., 1995). Invasive dental treatments, such as drilling, and

administration of local anesthesia can be risk factors for developing dental behavior-management problems in children (Milgrom et al., 1995, Jalevik and Klingberg, 2002). Recent investigations on central pain processing imply that the brain records pain experiences, allowing a path to persistent pain conditions (Fitzgerald, 2005). This calls for proper pain management in all dental care procedures.

The investigations here attempt to enlighten restorative treatment practices in real-life settings. In addition, dentists' views and perceptions and variation in restorative treatment practices were evaluated with regard to dentist-related factors.

## **2 REVIEW OF THE LITERATURE**

### **2.1 Restorative treatment practices**

The principal reasons for placement of restoration - primary and secondary caries, and restoration failures - have remained relatively unchanged during the last two decades. Some decades ago, restorative strategies described in textbooks were based mainly on empirical knowledge and current practice. Universal clinical practice recommendations regarding placement and replacement of restoration have been sparse, but evidence-based dentistry has begun to cover restorative treatment as well. Researchers and teachers worldwide have published proposed criteria for restorative quality evaluation that came to light in the proceedings of a symposium (Anusavice, 1989). Regarding restorative treatment, the World Dental Federation (FDI) has listed on its website dozens of dental recommendations and review articles such as “Quality of dental restorations” (Jokstad et al., 2001) and “Minimal intervention dentistry” (Tyas et al., 2000).

A common method for investigating restorative practices has been cross-sectional studies with a pre-designed form sent to dentists to record the materials and reasons for treatments along with routine clinical work during a limited time period. In Finland, the public authorities maintain stringent record-keeping practices, including patient's basic information, diagnosis, and treatments (Ministry of Social Affairs and Health, 2001). Dentists generally record a reason or diagnosis for restorative treatment, but these data are not collected as official statistics. Information has also been collected retrospectively from dental records of specific patient groups, or from insurance databases and payment claims regarding re-restorations or use of various materials.

#### **2.1.1 Initial placements**

Surveys involving dentists completing pre-designed forms on their restorative treatments have shown that one of the main reasons for placement of initial restoration is primary caries; in adults, this accounts for about half of the reasons and varies with patient-related factors such as age and country of residence (Table 2.1). In Finland, in a cross-sectional study involving adult patients in the private sector, one of four restorations had primary caries listed as the reason for placement of restoration, but among patients aged 17-29 years the main reason was primary caries (54%) (Forss and Widström, 2004). In Greece and Jordan, the majority of restorations have been placed because of primary caries, but in the UK and Brazil primary caries accounts for less than half of reasons in the 21st century (Table 2.1).

**Table 2.1** Studies exploring reasons for placement of restoration. The presented proportions are imported from the original publications or calculated from figures reported therein.

Study, year	Country	Restorations n	Sector	Patient age years	Primary caries %	Replacements %	Noncarious defects %
Mjör, 1981	Sweden	5487	Private	all	26	74	
Amalgam	1978-79	3527			29	71	
Tooth-colored		1960			21	79	
Qvist et al., 1986a,b	Denmark		Private	all			
Amalgam	1980-82	6052	Public		62	38	
Tooth-colored		883			53	47	
Qvist et al., 1990a,b	Denmark		Private	2-94			
Amalgam	1987-88	4932	Public		60	40	
Composite		25421			46	54	
Mjör et al., 1992a,b	Italy		Private	n.a.			
Amalgam		2960			59	41	
Composite		1025			52	48	
York et al., 1993	USA	4633	Navy	17-84	55	40	5
Amalgam		3623			56	41	3
Composite		747			47	41	12
Pink et al., 1994	USA	3472	GDP	18-81			
Amalgam					44	43	13
Composite					50	42	8
Friedl et al., 1994,1995	Germany		GDP	all			
Amalgam	1991	5240			47	53	
Composite		3375			51	49	
Browning et al., 1996	USA	1360	GDP	n.a.	34	57	9
Composite	1993						
Wilson et al., 1997	UK	2379	GDP	na			
Amalgam	1995	1076			35	64	1
Composite		880			19	60	21
Mjör, 1997a	Sweden	5779	GDP	adults			
Amalgam	1993-95	1244			13	87	
Composite		3450			20	80	
Glass-ionomer		1085			55	45	
Burke et al., 1999	UK	9031	VDP and trainee	n.a.	41	51	8
	1997						
Mjör et al., 1999	Norway	24429	Private	1-97	46	49	5
	1997		Public				
Deligeorgi et al., 2000	UK	1431	University students	>16	48	52	
	1996-97						
	Greece	1189	University students	>16	63	37	
	1996-97						
Forss et al., 2001	Finland	6322	Public	>17	35	56	9
	1997		Private				
Burke et al., 2001	UK	3196	GDP	7-96	28	66	6
Al-Negrish, 2001,2002	Jordan		GDP				
Amalgam	1997	3166		9-66	55	45	
Composite		2239		12-65	50	38	12
Mjör et al., 2002b	Iceland	8395	Private	all	45	47	8
Forss et al., 2004	Finland	3434	Private	17-94	24	65	11
	2000						
Tyas, 2005	Australia	2716	Private	3-94	32	54	14
Braga et al., 2007	Brazil	551	Private	7-85	23	60	17

GDP=General Dental Practitioner. working sector not specified

VDP=Vocational Dental Practitioner (UK)

In Finnish adolescents, primary caries accounted for 83% of reasons for placement of restoration in permanent teeth (Widström and Forss, 1994, Forss and Widström, 2003). Younger patients not having had the time to gather restorations that could be replaced explains these differences between age groups. Differences between countries are probably due to different socioeconomic situations, care provision systems, dentist's work-related traditions, eating habits, and use of fluoride (Nadanovsky and Sheiham, 1995, Marinho et al., 2003).

Other reasons for initial placement of restoration are noncarious defects, such as fractures, erosion, abrasion, and esthetic reasons, each accounting for less than 17% of reasons (Table 2.1). Noncarious defects have been shown to be more numerous the older the patient (York and Arthur, 1993, Ellis et al., 1999, Mjör et al., 2002b, Tyas, 2005). Cross-sectional studies from the UK (Burke et al., 1999) and Norway (Mjör et al., 1999) have reported that composites were used more often than amalgams or glass-ionomers (GI) in placing restorations for noncarious defects.

Regarding primary teeth in Finland, reasons for placement of restoration were primary caries in 80%, secondary caries in 8%, fractures in 11%, and other reasons in 1% (Forss and Widström, 2003). Among primary teeth in Norway and Iceland, the main reason for placement of restoration was primary caries, with figures of 86% and 83%, respectively (Mjör et al., 2002a, 2002b).

### **2.1.2 Replacement of restoration**

A failed restoration must be replaced or repaired. As many as one in five restoration may be re-treated every four years (Clarkson et al., 2000), leading to a continuous cycle, as discussed already in the 1970s (Elderton, 1976). Replacement strategy as described in textbooks usually means removal of the remnants of the failed restoration, frequently also involving removal of sound tooth structure, inevitably creating a larger restoration than the original one (Elderton, 1990, Cheetham et al., 1991, Gordan, 2001, Gordan et al., 2002).

Replacement of restorations accounts for half of all reasons for restorative treatment according to pre-designed forms completed by dentists (Table 2.1). Again, as for initial placements, variation occurs by country of residence; in Greece and USA, there have been fewer replacements, comprising about 40% of reasons, in contrast to 60-80% in the UK and Sweden (Table 2.1). Patient age influences the number of replacements; in Finland in the private sector, secondary caries, fractures, and loss of restoration were more frequent among patients aged 30 years and over than among patients aged 17-29 years (Forss and Widström, 2004). The prevalence of restorations in need of replacement was lower in the age group of 20-24 years than in the age group of 35-44 years in an epidemiological survey of 600 adults in the Netherlands (Kroeze et al., 1990). In addition, patient's gender influences replacement rates: for men, significantly more restorations were replaced than for women in a longitudinal study with 1213 amalgam restorations evaluated after a 15-year follow-up (Gruythuysen et al., 1996). In USA, a longitudinal randomized controlled trial (RCT) has recently shown that the higher the number of restorations in adolescents the greater the need for replacements (Soncini et al., 2007). In Finnish adolescents,

permanent teeth replacements of restoration accounted for 12% of all replacements in a cross-sectional study of the Public Dental Service (PDS) (Forss and Widström, 2003).

### **2.1.3 Reasons for replacement of restoration**

For permanent teeth, the reason predominantly given for replacement of amalgam or composite restoration has been secondary caries, accounting for 29-45% of reasons in cross-sectional studies (Allander et al., 1990, Al-Negrish, 2001, Burke et al., 2001, Al-Negrish, 2002, Mjör et al., 2002b, Forss and Widström, 2004, Tyas, 2005). By contrast, longitudinal prospective studies have most often cited minimal rates of secondary caries (Letzel et al., 1989, Raskin et al., 1999). Fractures of restoration or tooth have constituted 20-44% of the reasons for replacements (Qvist et al., 1990a, Mjör, 1997a, Mjör et al., 2002b, Forss and Widström, 2004, Tyas, 2005). Among adolescents, the major reason for replacement of restoration has been secondary caries, followed by fracture of restoration or tooth (Wendt et al., 1998, Bernardo et al., 2007, Soncini et al., 2007). Other reasons for replacement of restorations include marginal ridge discrepancy, poor anatomic form, discoloration, esthetics, erosion, abrasion, and patient request.

Secondary caries as the reason for replacement has been more frequent for amalgam than for composite restoration (Qvist et al., 1990a, 1990b, Mjör and Toffenetti, 1992a, 1992b, Mjör, 1997a). However, two recent radiographic studies among adults, one from Israel and the other from Denmark, have reported that caries was seen more often in relation to tooth-colored restorations than in amalgam restorations (Levin et al., 2007, Kirkevang et al., 2009). Indeed, among adolescents aged 8-12 years, a recent RCT from Portugal indicated that composites had 3.5 times greater risk of secondary caries than amalgam restorations (Bernardo et al., 2007).

Discoloration and marginal ridge discrepancy played a major role as reasons for replacement of anterior composites and silicates in the 1980s (Qvist et al., 1986a, Mjör and Toffenetti, 1992a, Friedl et al., 1995, Browning and Dennison, 1996), but nowadays these reasons have taken a back seat, as tooth-colored materials have improved. For GI and its derivatives (GIs), reasons such as secondary caries and marginal leakage or fracture have predominated (Mjör, 1997a, Burke et al., 2001, Forss and Widström, 2004, Tyas, 2005). For gold restorations, fracture of the tooth, inclusion into a larger restoration, and secondary caries have been the main reasons for replacement (Mjör and Medina, 1993).

In primary teeth, replacement rates have ranged from 9% to 35% in Nordic countries (Wendt et al., 1998, Mjör et al., 2002a, 2002b, Forss and Widström, 2003). Secondary caries has been the main reason for replacement among primary teeth, followed by fracture of restoration (Mjör et al., 2002a, Soncini et al., 2007).

Repair of restoration instead of removing the whole old restoration has been developed in an attempt to avoid unnecessary removal of sound tooth (Mjör, 1993). Recently published studies show that refurbishing or repairing failed amalgam and composite restoration is a good treatment alternative (Mjör and Gordan, 2002, Gordan et al., 2006a, 2006b, Moncada et al., 2006). Dental schools in Nordic countries teach this new repair

approach, but are in disagreement on the expected longevities of such repairs (Blum et al., 2003).

#### **2.1.4 Associated dentist-related factors**

Only a few studies of reasons for placement or replacement of restorations have evaluated the influence of dentist-related factors; these have mostly been reported secondarily, if at all.

Dentist's gender showed no dependence on the reasons cited for replacement of restorations by 91 dentists in a cross-sectional study from Iceland (Mjör et al., 2002b). No earlier studies are available from Finland regarding gender differences in replacement of restoration.

Influence of dentist's experience on the reason for replacement has been evaluated previously. A study from USA involving three private dentists aged 37, 45, and 52 years and evaluating replacement of 284 restorations revealed that the oldest dentist cited caries (primary or secondary) as the reason for replacement of posterior restorations more frequently than two younger dentists (Drake et al., 1990). The conflicting but stronger results of a cross-sectional study involving 91 dentists and over 8000 restorations from Iceland demonstrated, however, that fracture and discoloration as the reason for replacement of restoration were more frequent with experienced dentists, and a diagnosis such as secondary caries was less frequent the longer the dentist's experience (Mjör et al., 2002b). Other surveys have reported the influence of experience on the size of replacement of restorations (Drake et al., 1990) and replacement rates (Gruythuysen et al., 1996); in the studies, however, only three dentists were observed, limiting generalization of the results.

An association of dentist's working sector with the ratio of replacements has been pointed out in a cross-sectional survey from Finland involving 850 general dental practitioners (GDPs) (Forss and Widström, 1996); private practitioners (69%) compared with dentists in PDS (52%) more frequently performed replacements of restorations on adults. There was, however, no difference in the reasons for replacements between private sector and PDS dentists.

## **2.2 Selection of restorative material**

In general, the selection of material depends on several objective influences: patient and tooth factors and dentist and restorative treatment process factors. In addition, subjective factors include patient preferences, practice setting, professional training, and method of funding. Culture, traditions, and statutes in different countries are also involved in the process.

### 2.2.1 Direct materials

Amalgam, a combination of mercury and silver alloys, has been used in restorative dentistry for 170 years. It was practically the only commonly used restorative material available for stress-bearing surfaces until the beginning of the 20th century and was even used for restorations on incisors in the lower jaw. Amalgam is reasonably easy to use, durable, and inexpensive. However, disadvantages, such as low esthetic appeal, uncertain biocompatibility, and need for removal of healthy tooth structure for retention purposes, have substantially reduced its use.

The use of amalgam has markedly diminished over the last three decades. In Scotland, longitudinal data collected on 3586 restorations, placed in 505 adult patients during a 5.5-year period showed that the most commonly used material (64%) was amalgam (Elderton, 1983). It predominated as a restorative material worldwide until the early 1990s (Table 2.2). In Norway, the use of restorative materials in children was compared based on data of restored surfaces in five age groups (5, 9, 12, 15, and 18 years) in 1978 and 1995; in 1978 among 15-year-olds, 90% of restored tooth surfaces were filled with amalgam compared with 33% in 1995 (Wang, 2000).

An analysis of an administrative database with over 80 000 patients attending General Dental Services (GDS) in England and Wales during an observation period from 1991 to 2002 revealed that the majority (61%) of new restorations were amalgam (Lucarotti et al., 2005c). According to the nationwide dental health survey in 1998 in the UK among clinically examined dentate adults (n=3817), 84% of their teeth with restorations had amalgam (Pine et al., 2001).

However, in USA, Australia, and Scandinavia, the use of amalgam has been decreasing according to a survey reviewing literature published since 1998 with indications of the extent of amalgam and composite restorations (Burke, 2004). Since the early 1990s in Finland and Sweden, amalgam comprised less than one-third of new restorations placed on adults' teeth (Widström and Forss, 1994, Mjör, 1997b).

At the beginning of the 21st century in Finland, amalgam represented about 5% of all new restorations placed on adults' teeth according to a study among private dentists (Forss and Widström, 2004). In other parts of the world, use of amalgam persists (Table 2.2). From the UK, 32 GDSs have reported their use of restorative materials in 1999 (Burke et al., 2001). Of the restorations placed, 54% were amalgam, and amalgam represented 87% of Class II restorations. By contrast, amalgam represented 10% of materials at a private practice in Brazil (Braga et al., 2007). The authors noted though that their results might not be representative of Brazil as a whole due to the urban private clinic setting.

For children in Finland, amalgam is used in only 0.6% of new restorations in permanent teeth (Forss and Widström, 2003). Recent data on amalgam use among adolescents elsewhere are scarce, but in Iceland, where the overall use of amalgam was 29%, 36% of Class II restorations for adolescents were amalgam (Mjör et al., 2002b). In Norway, only 4.6% of Class II restorations were amalgam when placed in permanent teeth, the majority of patients being under 25 years (Vidnes-Kopperud et al., 2009).

As the first tooth-colored materials, silicate cements were introduced to dentistry at the beginning of the 20th century. A mixture of aluminosilicate glass and an aqueous solution



**Table 2.2** Studies on restorative materials used. The presented proportions are imported from the original publications or calculated from figures reported therein.

Study, year	Country	Restorations n	Sector	Patient age years	Amalgam %	Composite %	GIs %	Gold %	Other %
Mjör, 1981	Sweden 1978-79	5487	Private	all	74	26 <sup>1)</sup>			
Elderton, 1983	Scotland 1978-1982	3586	GDP	>16	64	32 <sup>2)</sup>			4
Qvist et al. 1986a,b	Denmark 1980-82	6999	Private Public	all	86	13 <sup>1)</sup>			1
Qvist et al. 1990a,b	Denmark 1987-88	7502	Private Public	2-94	66	31	2	1	
Mjör et al., 1992a,b	Italy	2960	Private	n.a.	65	35			
York et al., 1993	USA	4633	Navy	17-84	78	16	1		5
Mahmood et al., 1994 <sup>4)</sup>	Pakistan Australia	622 966	Private Hospital	adults adults	39 47	18 21		19 8	24 24
Widström et al., 1994	Finland 1992	7481	Private Public	adults	29	47	24		
Fiedl et al. 1994,1995	Germany 1991	8794	GDP	all	60	38			2
Wilson et al., 1997	UK 1995	2379	GDP	n.a.	45	37	18		
Mjör, 1997b	Sweden 1993-95	5779	GDP	adults	21	60	19		
Hawthorn et al., 1997 <sup>3)</sup>	Australia	2931	Private	adults	59	16	9	2	14
Burke et al., 1999	UK 1997	9031	VDP and trainees	n.a.	54	30	16		
Mjör et al., 1999	Norway 1997	24429	Private Public	1-97	32	40	25		3
Deligeorgi et al., 2000	UK 1996-97 Greece 1996-97	1431 1189	University Students University Students	>16 >16	49 44	33 51	15 5		
Forss et al., 2001	Finland 1997	6322	Private Public	>17	5	75	19		1
Burke et al., 2001	UK	3196	GDP	7-96	53	32	15		
Mjör et al., 2002b	Iceland	8395	Private	all	29	53	17		1
Hu et al., 2002	Taiwan	25293	GDP	1-84	42	44	14		
Forss et al., 2004	Finland 2000	3455	Private	17-94	5	79	11		5
Tyas, 2005	Australia	2716	Private	3-94	28	55	17		
Braga et al., 2007	Brazil	551	Private	7-85	10	89	1		

GDP=General Dental Practitioner, working sector not specified

GIs=Glass-ionomer and its derivatives

VDP=Vocational Dental Practitioner (UK )

1) tooth-colored

2) synthetic material s

3) retrospective longevity data

of phosphoric acid formed the basis for these cements meant for restorations of the anterior teeth. Due to the number of problems with silicates, including adverse pulpal reactions, staining over the long term, brittleness, and poor resistance to saliva, they were superseded in the 1970s by composite (resins), originally invented in the 1950s.

Composites are based on a mixture involving (monomer) resin (Bis-GMA and later also TEGDMA) and inorganic filler particles. Chemical (activator) or visible blue light exposure activates polymerization, which usually causes some unwanted material contraction. Other downsides include technique sensitivity; prior placement tooth surfaces need acid etching and bonding, and good moisture control. However, excellent esthetic properties and minimally invasive removal of tooth structure have surely influenced the popularity of composites.

Composites were initially used as single surface restorations in Class III and V cavities primarily (Elderton, 1983, Qvist et al., 1986a), but in the early 1990s their use expanded to posterior load-bearing surfaces in conjunction with the application of small occlusal “preventive” restorations (Ripa and Wolff, 1992). A cross-sectional study involving 22 practitioners from the UK reported that one in five new composite restorations was a Class I or II restoration in the early 1990s (Wilson et al., 1997). At that time, composites overall comprised around 40% of materials used among adults in Finland (Widström and Forss, 1994). By 1997, the proportion of composites had risen to 75% in adults in Finland, as described in a cross-sectional survey (Forss and Widström, 2001). A study from Norway reported that 76% of new Class I restorations in 1997 were tooth-colored (Mjör et al., 1999). In Taiwan, based on the National Health Insurance Research database in 1997, a study on direct restorative materials for posterior teeth reported that 27% of composites were placed on posterior teeth and 64% of composites were one-surface restorations (Hu et al., 2002). With regard to the proportion of composites placed on adults' teeth, Sweden has been a pioneer; in 1993-1995, 60% of new restorations were composites (Table 2.2).

In Norway, 27% the restored surfaces among 15-year-olds' permanent teeth in 1995 comprised composites (Wang, 2000). In Finland, for children attending PDS in 1992, composites constituted 30% of restorative materials used for permanent teeth; by 1997, the proportion of composites had risen to 59% (Forss and Widström, 2003).

At the beginning of the 21st century, composites were a part of everyday dentistry, comprising 53-89% of materials in numerous countries, excluding the UK (32%) (Table 2.2). In Australia, a cross-sectional survey on 28 selected GPs and nearly 3000 restorations revealed that 55% of the restorations were composites (Tyas, 2005). In Finland, 79% of adult restorations placed in the private sector were composites, predominating in all cavity sizes and constituting 67% even in extensive cavities (Forss and Widström, 2004). This undoubtedly means heavy use of composites in the load-bearing surfaces of posterior teeth.

Studies reporting recent composite use in children's permanent teeth are rare. In Iceland, where the overall use of composite was 53%, altogether 51% of Class I restorations of adolescents were composite (Mjör et al., 2002b). A recent study from Norway reports that 82% of Class II restorations were composites of a total of 4030 Class II restorations placed during 2001-2004 in permanent teeth, the majority of patients being young adults under the age of 25 (Vidnes-Kopperud et al., 2009).

Glass ionomer (GI) and its derivatives are tooth-colored materials as well. GI cements were invented in the 1960s, when biocompatibility became an important factor in dental materials. GI cements were originally formulated from a glass powder containing fluoride, which reacts with a poly (alcanoid) acid. This conventional GI shows fluoride release and uptake and is considered to be anticariogenic. Unlike silicate, GI adheres to tooth structure without prior treatment with bur or bonding agents. However, GI requires proper moisture isolation before and after placement and is brittle when set. Adding silver powder and forming so-called silver cermet, e.g. Ketac-Silver®, which was not tooth-colored, was an attempt to improve GI's mechanical properties, but it failed to gain popularity. In the 1990s, GI was combined with composite to formulate resin-modified GI and compomers – the latter of which are principally composites as they do not set in the dark and need a hydrophilic bonding system. The conventional GI and its derivatives (GIs) were first used for restorations in primary teeth. In Denmark in 1987-1988, 6% of 2542 tooth-colored restorations placed have been GI, mostly Class II restorations in primary teeth (Qvist et al., 1990b). Gradually, the use of GI has spread to Class V cavities in permanent teeth. In the 1990s, the use of GI attained its highest rates in Finland and Norway, around 25%, and the lowest in Greece and Australia, 5-9% (Table 2.2).

In 1992, GI was used in 47% of permanent teeth of children needing restorations in the PDS in Finland (Widström and Forss, 1994). Similarly, a few years later in Norway, most surfaces of the permanent teeth of children and adolescents were restored with GI: 56% among 9-year- and 39% among 15-year-olds (Wang, 2000). However, in Finland by 1997, the proportion of GIs had decreased to 40% among children (Forss and Widström, 2003) and to 19% among adults (Forss and Widström, 2001).

At the beginning of the 21st century, among the restorative materials used, the share of GIs was highest in Iceland and Australia (17%) and lowest in Brazil (1%) (Table 2.2). In Finland, 11% of materials used for adults were GIs (Forss and Widström, 2004). Recent studies among adolescents are, however, rare. In Norway, GIs comprised 14% of Class II restorations in permanent teeth of young adults (Vidnes-Kopperud et al., 2009).

Gold has been in use for restorations longer than amalgam. Pure gold is soft and for placing a restoration gold foils are heated and inserted into the cavity, mainly Class III and V, and then compacted together to form a restoration. Gold mixed with certain alloys can also be used as cast restorations made by a dental technician. Both techniques are time-consuming, the cost being much higher than for amalgam or composite. Gold restorations are an exception in ordinary dental practice even in industrialized countries (Table 2.2). In cross-sectional studies, gold restorations have often been grouped in the material section “other”, as in a study from Norway, where other materials including gold castings, porcelain inlays and temporary fillings comprised 3% of over 24 000 restorations placed by private practitioners and by dentists in PDS in 1997 (Mjör et al., 1999). Data from US Naval Dental Clinics revealed only 7 (0.2%) gold foil restorations among 4633 restorations (York and Arthur, 1993). In Finland, 3% of restorations placed in the private sector were gold inlay or onlay in 2000 (Forss and Widström, 2004).

In primary teeth in Norway, 99% of restored surfaces were filled with amalgam in 1978 (Wang, 2000). In 1992 in Finland, amalgam was used as a restorative material for 7% of primary teeth needing restoration, and GI and silver cermet for the rest (Forss and

Widström, 2003). Three years later, amalgam was used for 4% of primary teeth restorations of 8-year-olds in Sweden, the primary material being GIs (58%); interestingly, every fourth restoration was a temporary one (Wendt et al., 1998). At the same time in Norway, GIs comprised 84% of restorative materials placed in primary teeth, and amalgam only 5% (Mjör et al., 2002a). In Finland in 1997, restorations placed in 96% of primary teeth comprised GIs and no amalgam (Forss and Widström, 2003). No studies exist from the 21st century regarding materials in primary teeth in Finland.

## **2.2.2 Professionals' opinions on materials**

Theoretical education for undergraduates, professional training, continuing education, and official recommendations by health authorities and dental associations modify dentists' treatment practices and beliefs. The main method for examining dentists' and dental schools' views and perceptions has been questionnaire studies.

Preclinical teaching at an American dental school on posterior restorations has favored amalgam over composite (Ottenga and Mjör, 2007); however, during the 3-year clinical phase, students more frequently placed composites than amalgam. According to a comparison of surveys of the teaching of posterior composites at dental schools in USA, Canada, Ireland, and UK, the content and share of composites in teaching from 1997 to 2004-2005 have increased markedly (Lynch et al., 2007).

Regarding primary teeth, a questionnaire survey administered to dental schools in Europe revealed that amalgam was a first-choice restorative material only in Eastern Europe, with none of the Scandinavian schools preferring amalgam (Buerkle et al., 2005). One of three dental schools in Europe favored GIs for Class I and II restorations in primary molars (Buerkle et al., 2005), but at North American dental schools the preferred material was amalgam (Guelmann et al., 2001).

Restrictions on amalgam use or instructions to diminish amalgam use because of environmental side-effects have recently been given by authorities in some countries (Burke, 2004). In Norway, dentists have been denied use of amalgam from 2008 onwards. The Swedish Government has banned amalgam from June 2009 onwards from ordinary dental treatment and is about to restrict the use of amalgam to only exceptional adult cases until 2012. The European Union (EU) and FDI have approved the World Health Organization (WHO) consensus statement on dental amalgam (WHO, 1997). As a result, the EU has not denied use of amalgam, but health authorities in some European countries, e.g. Finland, UK, and Germany, have implemented "recommendations concerning the use of amalgam in the dental care of children and pregnant women" (Burke, 2004). In the USA, the American Dental Association (ADA) Council on Scientific Affairs (1998a, 1998b) has concluded that amalgam and composite are both safe and effective for tooth restoration. However, in the Netherlands, one dental school has stopped instruction on and use of amalgam (Roeters et al., 2004).

The Scandinavian Institute of Dental Materials (NIOM) has tested and recommended materials for use in dental care in the Nordic countries. Before entering the EU, all Nordic

countries relied on these recommendations. Today, the safety and appropriateness of dental materials are the manufacturers' responsibility in the EU.

Dentists' views and beliefs on restorative materials have been mostly assessed by questionnaire studies. In Finland in 1990, 5% of respondents in a survey of 454 GDPs agreed with the statement "the use of amalgam should be prohibited as early as 1993" (Widström and Forss, 1991), and 97% reported having amalgam restorations themselves (Widström and Sundberg, 1991). In the Netherlands, 5% of dentists attending a Dental Congress in 1994 were against the use of amalgam and 9% didn't have an opinion (Schuurs et al., 1996). Swedish dentists, compared with dentists from other Nordic countries, have had more negative attitudes towards the use of amalgam (Widström et al., 1993). Further, amalgam was chosen by only 3% of Swedish dentists in a questionnaire regarding routines for treatment of occlusal caries in 1995-1996 (Espelid et al., 2001). In Finland, 43% of dentists agreed with the statement "the use of amalgam can be stopped by the year 2000", and 39% of private sector dentists have reported discontinuing the use of amalgam (Widström and Forss, 1998). In Denmark, however, the proportion of dentists using amalgam "often" for adults was 74% in 1998 (Ylinen and Löfroth, 2002).

UK dentists have indicated that amalgam predominates for Class II restoration in premolars and molars (Wilson et al., 2004). Only 16% of dentists in England and Wales recently stated that they use "always or often" composite on large restorations in molars (Burke et al., 2003), compared with 41% of dentists participating in a survey in Australia (Burke et al., 2004). A recent questionnaire-based investigation suggests, however, that posterior composite restorations are on the rise also in the UK (Gilmour et al., 2007). A recently published survey on dentists in the USA indicated that one-third of dental practices were totally amalgam-free; among respondents still using amalgam, 51% reported using composite restorations in posterior load-bearing surfaces (Haj-Ali et al., 2005).

Amalgam and composite have produced speculation among dentists regarding possible side-effects (Widström et al., 1993, Schuurs et al., 1996, Ylinen and Löfroth, 2002) and materials' similar longevity (Widström and Forss, 1998, Burke et al., 2003, 2004). With respect to the use of gold, half of private practitioners in Finland (Widström and Forss, 1998) and 25% in the UK (Burke et al., 2003) reported using no gold materials.

Regarding the choice of material, clinical indications are the most influential factor based on a questionnaire study among dentists in the UK (Burke et al., 2003). Patients' opinion, financial situation (Burke et al., 2003), esthetics (Espelid et al., 2006), future treatment plan involving partial denture or bridge, the restoration's role in occlusion, and prognosis (Brennan and Spencer, 2006) influence the choice of materials. For failed posterior restorations, Finnish GDPs' choice was amalgam in 10%, gold in 2%, and composite in 88% of cases when assessed by a questionnaire study (Heinikainen et al., 2002). American dentists have said that their molar cases are mostly restorations of amalgam (36%), with the minority being composite (7%). Other materials comprise 20%, and gold 13%, and 22% of their molars are untouched and sound (Rosenstiel et al., 2004).

For primary teeth, pediatric dentists in Florida selected amalgam for Class I and II restorations only in 20% and 28% of cases, respectively, as shown in a questionnaire study (Guelmann and Mjör, 2002). In California, 57% of pediatric dentists stated that their

material selection for Class II cavities in primary molars was amalgam (Pair et al., 2004), while 21% claimed never using amalgam in this situation.

### **2.2.3 Dentist-related factors regarding material selection**

Cross-sectional studies have evaluated influences of dentist-related factors on material selection, but clarifying these factors has often been secondary. For replacement of restoration among children in Sweden, the type of restorative materials varied greatly between 11 PDS clinics, but reasons behind the variation remained unresolved (Wendt et al., 1998). Questionnaire studies have evaluated dentists' perceptions of the usefulness of materials, and sometimes assessed dentist-related factors as well.

Influence of dentist's gender on material selection has been assessed by cross-sectional studies and questionnaires. In one cross-sectional study from Iceland evaluating the material selection of 91 dentists (Mjör et al., 2002b) and in another from Norway involving 243 dentists (Mjör et al., 1999), gender had no impact on material selection. In Finland in 1992 among children aged 0-16 years, dentists' gender was unrelated to the use of amalgam in a cross-sectional study based on routine clinical work in PDS (Widström and Forss, 1994). However, according to another cross-sectional survey in Finland, female dentists reported seeking patient's opinions on material selection more often than male dentists (Forss and Widström, 1996).

On the other hand, according to a questionnaire study in the UK, male dentists reported more often than females that they "always or often" used composite for large posterior restorations (Burke et al., 2003). Similar results were uncovered by an inquiry among Finnish private practitioners, where a higher proportion of male than female dentists reported discontinuing the use of amalgam (Widström and Forss, 1998). Regarding child patients, however, female dentists at pediatric dental clinics in Florida reported using less amalgam for primary molar restorations than male dentists (Guelmann and Mjör, 2002).

Investigating the impact of dentists' age or length of professional experience on material selection has produced conflicting results. Dentists' age was unrelated to the use of amalgam in children aged 0-16 years in PDS in Finland in 1992 (Widström and Forss, 1994); the same was true for patients aged 6-57 years according to a study on 27 dentists in PDS in Norway (Vidnes-Kopperud et al., 2009). Similarly, dentists' age had no correlation with dentists' self-reported use of amalgam in Finland when investigated by questionnaire (Widström and Forss, 1998). On the other hand, an evaluation based on a questionnaire study of 590 dentists in Sweden reported that the age of dentists was related to material selection: older dentists chose amalgam and GI more frequently than younger dentists (Sundberg et al., 2000). This conflicts with results from a recent questionnaire study from England and Scotland, where younger dentists in terms of years since graduation stated applying GI for restorations more often than older dentists (Wilson et al., 2004). When dentists' subjective opinion on amalgam was assessed in Nordic countries in the 1990s, amalgam was considered as having "very high or high risk of side-effects" by a larger proportion of dentists aged under 40 years than older dentists in a questionnaire

study (Widström et al., 1993). However, regarding other materials as well as amalgam, dentists over 40 years reported seeking patient's opinion on material selection more often than younger dentists in a cross-sectional survey from Finland (Forss and Widström, 1996).

The influence of dentist's working sector on the selection of restorative material was evaluated in the late 1990s in Finland and Sweden; PDS dentists more often than private practitioners wanted to keep amalgam available, as evidenced by a questionnaire survey (Ylinen and Löfroth, 2002). This was supported by a cross-sectional study in the UK where higher percentages of amalgam were placed in the Army and NHS than under Private and Private/Capitation arrangements (Burke et al., 2002). In Finland and also in Sweden, cross-sectional studies have shown that private practitioners used composites more often than PDS dentists (Forss and Widström, 1996, Mjör et al., 1999), and in Finland GI was placed more often by PDS dentists than by private practitioners (Widström and Forss, 1994). However, only a weak influence of dentists' opinions on choice of restorative materials was observed; the perceived competence in using gold was higher among private practitioners than among PDS dentists (Widström et al., 1993). In line with this, a questionnaire study in Finland reported that private practitioners compared with PDS dentists favored indirect restorations more strongly (Heinikainen et al., 2002).

Legislation on patients' rights since 1992 in Finland requires that patients be treated with mutual understanding, and the opinion of children must be sought at an age- or development-appropriate level. In a questionnaire study, private dentists more often than PDS dentists reported discussing the choice of material with patients (Ylinen and Löfroth, 2002). This is in line with an earlier cross-sectional survey in Finland, where private practitioners reported seeking the patient's opinion on material selection more often than PDS dentists (Forss and Widström, 1996).

## **2.3 Restoration longevity**

### **2.3.1 Evaluation of longevity**

Restoration longevity has been evaluated by longitudinal prospective, retrospective, and cross-sectional studies. The numerous laboratory studies are not reviewed here, as they are beyond the scope of this thesis.

Longitudinal prospective or historical studies usually take place at universities or dental schools, where treatment practices follow scientific golden standards and patients are more loyal to dental schools as caregivers than in ordinary dental service; time allotted to procedures is not limited, and patients are motivated to keep up good oral hygiene.

In prospective studies, sometimes referred to as controlled clinical trial (CCT) or RCT, a group of selected patients receives specific restorations placed by calibrated dentists. The same dentists review the restorations (e.g. every year) and use standardized codes and criteria, such as those of the United States Public Health Service (USPHS) or modified USPHS. USPHS classifies restoration assigned the rating "Charlie" for dentin or base

exposure or “Delta” for mobile, fractured, or missing restorations, as failure (Ryge, 1980). Longitudinal studies include information on failed restorations as well as on those that do not fail. The follow-up period rarely exceeds 10 years: the longer the follow-up, the higher the dropout rate and expenses.

A historical or retrospective study comprises data from patient records collected in earlier years. Collection of data on many restorations is relatively easy, and patients’ charts can be considered a reliable source of information (Marshall, 1995). However, detailed information about the reason for re-restoration can be missing, and re-treatment at another dental clinic is unknown.

Pre-designed forms sent to GDPs enable data collection in cross-sectional studies, sometimes referred to as practice-based studies (PBS) or community trials. Dentists complete recordings of restorative procedures for a limited time period. There is no standardization among dentists as regards diagnostic criteria, and restorative materials vary. Information attained includes failed restorations only, not those surviving. Despite of low response rates, the large amount of data that can be collected in a short time is an advantage.

No consensus exists about which study method is most reliable; some prefer CCT (Downer et al., 1999). Results from highly controlled studies performed at dental schools or hospitals cannot be readily generalized to “real life” dental practice (Burke and McCord, 1993). However, practice-based research networks could collect a sufficient amount of data and at the same time have control over the operator effects (Hickel et al., 2007, Mjör, 2007, Derouen et al., 2008).

Inquiry of dentists on restoration longevity produces estimates only. Respondents’ recent experience, the literature, or personal opinions can influence these estimates. However, information on expected longevity is important for quality of care and for development of minimum standards of longevity.

A literature review-based assessment, which uses results from several clinical studies and meta-analyses, gives additional information to single studies. Selection of high-quality studies on longevity characterizes this approach. The outcome of the review depends on the validity of the investigated studies. As described above, methods vary; restoration failure criteria and representation of results are not necessarily unified. Review studies have had difficulties giving an unambiguous answer to the question of longevity (Mjör et al., 1990, Downer et al., 1999, Hickel et al., 2000, Hondrum, 2000, Chadwick et al., 2001, Manhart and Hickel, 2001, Brunthaler et al., 2003, Manhart et al., 2004). Evidence-based literature research by the Cochrane collaboration has to date no published results (Lu et al., 2006).

### **2.3.2 Terminology**

The age of restoration is a measure of longevity of restoration. In cross-sectional studies, where information is attained on failed restorations only, the common indices of results are median and mean ages of failed restoration. If the mean age is calculated, it is affected by a few very long-lasting restorations in the pool; mean age is therefore usually longer



than median age due to the appearance of positively skewed distribution of survival time of restorations. Reporting the quartiles of the survival distribution gives information about the deviation from the mean (Leempoel et al., 1989). It is not always possible to attain a history of every failed restoration due to missing patient records; the calculated mean value is thus lower than the actual mean. Median age describes longevity of restorations that are still functioning in situ (Jokstad et al., 1994) or indicates the function period of 50% of the failed restorations. This is also referred to as the median functional period of failed restoration (Downer et al., 1999). Due to a skewed distribution of the survival time of restorations, median age with quartiles is preferred. In retrospective cross-sectional studies, the age of the patient and the length of dental history must be considered when assessing longevity (Jokstad et al., 1994). The age of restoration at replacement often correlates with the patient's age: the older the patient, the older the restoration in need of replacement (Burke et al., 2001).

Survival or failure rates are commonly used terms in clinical studies where all placed restorations are recorded, such as in longitudinal or retrospective studies; data include information on restorations that have failed and those still in service. The number of replaced restorations divided by the number of initial placements and multiplied by 100 gives the failure rate percentage. To describe the survival rate, the failure rate is subtracted from 100. Restorations lost to follow-up are problematic; an assumption of their behavior resembling surviving restorations is one possibility. Survival or failure rates can also quantify restoration survival time by e.g. 5-year or 10-year survival chance if the survival time appears to be significantly longer than the study follow-up. Likewise, the term "replacement rate" has been used to describe the outcome of restoration performance, but this usually includes restorations in need of replacement as well as already failed and replaced restorations, e.g. in epidemiological studies. Replacement rate can be given in year(s) as well.

The Kaplan-Meier methodology analyzes incomplete survival data. In prospective longitudinal studies, it has been used in giving each restoration the date of 'life' or 'death'. An advantage is that all data can be used, but an overly optimistic view of survival or either a lower-than-expected survival may result. To overcome failures in this approach, a modified Kaplan-Meier analysis was devised (Lucarotti et al., 2005b, 2005c), taking into account patient censoring and calculated intervals between successive interventions of individual teeth within a GDS of the UK as a whole, not just re-attendance with the same dentist. For deciding the "life" of a restoration, this approach involved the dentists' decision to intervene and not standard criteria such as USPHS.

The term clinical longevity (CL50) introduced by Bayne (1991) refers to the clinical longevity values for 50% survival, i.e. the time to failure for half of the restorations in the pool. This method can be applied in multiple studies including the same type of restorations with numerous confounding factors. A multifactor analysis of CL50 then provides curves related to factors contributing to restoration failures. The shape of the curve is dependent on the survey method, whether it is CCT or PBS. Failure curves do not have the same CL50 in the CCT and the PBS (Bayne, 2007).

### 2.3.3 Restoration longevity in permanent teeth

Longevity of amalgam restoration in posterior teeth has been investigated extensively. During the 1980s in the Netherlands, a retrospective study assessed the survival of 2660 Class I or II amalgam restorations from six different clinical trials, resulting in overall survival rate of 94% (Letzel et al., 1989). In Finland, a cross-sectional study evaluated 767 amalgam restorations in molars among university students; 10% of restorations needed replacement and their mean age was 7.3 years at the time of replacement (Rytömaa et al., 1984). In Sweden, a retrospective longitudinal study evaluated the longevity of posterior amalgam restorations among long-term recall patients; after 17 years, the probability of not being replaced was 78%, but the estimated time of 90% survival was 7 years (Bjertness and Sonju, 1990).

More recent studies also exist. A controlled, longitudinal study from the Netherlands involved three dentists and evaluated the performance of 1117 Class II amalgam restorations; during a 15 year follow-up, 17% of restorations were replaced (Kreulen et al., 1998). In Belgium, a prospective longitudinal study of extensive posterior amalgam restorations reports a median survival of 12.8 years after performing Kaplan-Meier analysis on the data (Van Nieuwenhuysen et al., 2003). In Finland, the median age of failed amalgam restoration was nearly 12 years for patients attending GDPs when assessed in a cross-sectional study in 1997 (Forss and Widström, 2001), and 15 years according to a survey on the private sector (Forss and Widström, 2004). In Portugal, an RCT of posterior amalgam restorations reported a survival rate of 94% at 7 years in permanent teeth (Bernardo et al., 2007), but this study involved only children.

Composite longevity studies during the early 1990s have concentrated mainly on anterior Class III-V restorations. In Italy, the median age of failed restorations was 3.3 years in a cross-sectional study assessing 262 composite restorations (the majority being Classes III-V) (Mjör and Toffenetti, 1992a). A cross-sectional study in USA reported the overall median age of failed composite restorations to be 6 years, but the median ages were 10 years for Class III and 5 years for Class IV and V restorations (Browning and Dennison, 1996).

Regarding posterior teeth, composite longevity studies date back a decade. In Norway, a retrospective study on the private sector evaluated 1209 posterior Class I and II composites after a period of 4.5 years, resulting in a survival rate of 87%, the 50% survival time being approximately 9 years during the 4-year period (Geurtsen and Schoeler, 1997). In Portugal, an RTC gave a survival rate of 86% at 7 years for posterior composite restorations for children aged 8-12 years (Bernardo et al., 2007). Performance of composite restorations placed by dental students has been evaluated in two studies; in the Netherlands, a retrospective study (1993-1995) among dental school patients reports a 5-year survival rate of 87% and a mean annual failure rate of 3% for 703 posterior Class I and II composite restorations (Opdam et al., 2004). In Germany, posterior composites placed by dental students were assessed after 3 years, 87% being acceptable according to modified USPHS criteria (Manhart et al., 2000).

In Belgium, prospective longitudinal data yielded a median survival time of 7.8 years for extensive posterior composite restorations based on Kaplan-Meier methodology (Van

Nieuwenhuysen et al., 2003). In Finland, a cross-sectional survey of private sector adult patients reported 6 years as the median age of failed composite restoration (Forss and Widström, 2004). Only a few studies have reported posterior composite median longevity of over 15 years; in USA, 130 ultraviolet light-cured small-, to medium-sized posterior composites were placed in the late 1970s by two clinicians and evaluated annually. After 17 years, 65% of restorations were recalled, and 76% of them were clinically acceptable (Wilder et al., 1999).

The median age of GI restorations was slightly over 4 years in a cross-sectional study among private and public dentists in Finland (Forss and Widström, 2001). The ages of 117 failed tooth-colored restorations in permanent teeth of children were evaluated in a cross-sectional study; the mean age for failed GI restoration was 3.5 years and for resin-modified GI 2.9 years in 1997 (Forss and Widström, 2003). However, recent cross-sectional data from the private sector on adult patients yield 7 years as the median age of failed GIs restoration (Forss and Widström, 2004).

### **2.3.4 Factors affecting longevity**

Patient-, dentist-, and material-related factors affect restoration longevity. The roles of these factors have been evaluated primarily in longitudinal and cross-sectional studies. In the former, the confounding factors can be reduced and the dentist effect controlled for with a strict research environment. Longitudinal studies are superior in assessment of patient and material factors. Cross-sectional studies in turn, yield more information about dentist-related factors, as a large number of dentists are involved, and this may give a more “real-life” picture of longevity. However, longevity of different materials cannot be reliably compared between cross-sectional studies because of a lack of unified instructions in material handling, moisture control, and failure criteria. Moreover, dentists’ diagnostic skills and treatment decisions are known to vary (Elderton and Nuttall, 1983, Nuttall and Elderton, 1983, Bader and Shugars, 1995). In addition, the impacts of operator and patient factors have often been carried out as secondary analyses, and therefore, whether relationships were negative and not reported or whether they were not analyzed in the first place remains obscure.

As patient-related factors, high or excessive occlusal function (i.e. clear erosion or abrasion of tooth surfaces), oral hygiene, DMFT, number of restored surfaces, gender, age, and type of tooth have all been associated with restoration performance and therefore longevity.

Restoration longevity was shorter among patients with high occlusal function than among patients with normal occlusal function (Burke et al., 2001, Tyas, 2005). Patients’ high caries susceptibility (Tyas, 2005), poor oral hygiene (Burke et al., 2001), and high DMFT (Gilthorpe et al., 2002) were indicators of increased risk of early restoration failure. Restorations have had a slightly higher median age among female than male patients (Mjör et al., 2000a).

Impact of patient age on longevity remains unclear. The majority of studies have reported a slightly shorter restoration longevity among older patients than among younger

patients (Plasmans et al., 1998, Van Nieuwenhuysen et al., 2003, Burke et al., 2005b, Janus et al., 2006). A clinical trial comparing two dentin bonding agents for class V composites has shown that retention loss was higher in the oldest age groups (Bayne et al., 1991). Likewise, patient age influences restoration survival; for older patients, the interval to restoration re-treatment was shorter for half a million direct restorations in England and Wales (Burke et al., 2005b). On the other hand, amalgam survival has been found to be highest in the youngest (< 20 years) and oldest (> 60 years) age groups, composite survival being the lowest in these age groups (Hawthorne and Smales, 1997).

Results of the impact of the size of restoration on longevity are conflicting. Several studies have indicated that longevity is shorter for larger restorations (Qvist et al., 1990a, Akerboom et al., 1993, Friedl et al., 1994, Jokstad et al., 1994, Friedl et al., 1995, Kreulen et al., 1998, Van Nieuwenhuysen et al., 2003, Bernardo et al., 2007, Opdam et al., 2007). Strong evidence comes from USA, with an RCT showing that the need for replacement of amalgam and composite restoration in permanent teeth was more frequent with larger restorations (Soncini et al., 2007); however, restorations in this study were for children. In adults, a longitudinal study of over 400 Class II amalgam restorations followed for 7-10 years found no differences in survival between MO, DO or MOD restorations (Jokstad and Mjör, 1991). A systematic review concluded that regarding amalgam restorations, small restorations survived as long as large ones (Chadwick et al., 2001).

Regarding the impact of type of tooth on longevity, several studies have shown that longevity is shorter among molar than premolar restorations (Akerboom et al., 1993, Kreulen et al., 1998, Lundin and Koch, 1999, Pallesen and Qvist, 2003, Janus et al., 2006). Nevertheless, in the Netherlands, in a study of 1213 Class II amalgam restorations over 15 years, replacement rates for MO/DO in premolars were 13% and in molars 15%. The corresponding figures for MOD were 19% and 22% (Gruythuysen et al., 1996); however, significantly more MOD than MO/DO restorations were replaced. In addition, evaluations of posterior composites after a 5-year (Kohler et al., 2000) and a 10-year (Raskin et al., 1999) follow-up revealed no influence of tooth type on survival.

Patients' treatment history can influence longevity of restoration. In a study of GDS in England and Wales, for frequent attenders with a median interval under 5 months between treatment courses, restoration survival rate was 31% at 10 years compared with 60% for less frequent attenders with more than 13 months between treatment courses (Burke et al., 2005b). In Scandinavia, however, no difference was seen between regular or irregular attenders in a cross-sectional study of 423 patients (Jokstad et al., 1994), but only 40 patients were irregular attenders. Restoration longevity may be shorter among regularly attending patients in a population with high proportion of replacements of restoration (Mjör et al., 2002b).

Influence of the method of funding on the restoration longevity has been evaluated in the UK. Restorations placed under the NHS had a shorter longevity than restorations placed under other arrangements, and further, restorations placed in the Army had the highest longevity when evaluated by means of a cross-sectional study (Burke et al., 2002). This is in line with the results of GDS study in England and Wales over an observation period of 11 years, where survival of over half a million restoration among adults (n=80 443) was slightly lower for non-paying than full-charge patients (Burke et al., 2005b). The

authors suggested that the explanation lies in socioeconomic status; paying patients may belong to a higher social group than non-paying patients. Oral health behavior may be more consistent among the high-income group (Kelly et al., 2000).

Dentist-related factors comprise gender, experience, and working sector. Assessment of the influences of these factors on longevity of restorations has not been performed routinely. Several studies have indicated that the operator defines the fate of restoration significantly, but factors related to this phenomenon remain unclear (Letzel et al., 1989, Kreulen et al., 1998, Wendt et al., 1998). Two studies from the Netherlands reported no influence of the dentist on the survival of nearly 3000 amalgam or composite restorations (Opdam et al., 2007) or on the survival of extensive amalgam restorations after an 8-year follow-up (Plasmans et al., 1998). It is questionable, however, whether valid conclusions can be drawn since these comparisons covered only a few dentists.

Gender differences were investigated in a study from Norway reporting age of 6761 replaced restorations; restorations replaced by male dentists had higher median ages (10 years for amalgam, 8 years for composite) than restorations replaced by female dentists (9 years for amalgam, 5 years for composite) in PDS (Mjör et al., 2000a). However, an analysis of an administrative database with over 80 000 patients attending GDS in England and Wales over an 11-year observation period found no relationship of dentist's gender with time from initial restoration to re-intervention (Lucarotti et al., 2005c).

The influence of dentists' clinical experience on restoration longevity is contradictory. In Australia, the youngest dentists had the highest longevity and the oldest the lowest for composites in a retrospective study involving 20 male private practitioners (Hawthorne and Smales, 1997). This finding was supported by an analysis of an administrative database from England and Wales of over half a million restorations, revealing that time from the restoration's initial placement to re-intervention was shorter for older than younger dentists (Lucarotti et al., 2005a). However, the opposite results were observed in other studies. A recent Swedish survey of 99 PDS dentists and 1474 restoration replacements indicates that dentists with less professional experience perform earlier re-treatments than more experienced colleagues (Sunnegårdh-Grönberg et al., 2009). In Norway, a cross-sectional study with 243 dentists reported lower median ages of over 6000 replaced restorations by less experienced dentists than dentists with over 30 years of clinical experience (Mjör et al., 2000a). In addition, a questionnaire study in USA reported that more years in practice were associated with longer average longevity estimates among GDPs (Maryniuk and Kaplan, 1986). These differences might be due to discrepancies in study settings.

Professional status is closely linked to years since graduation and age of dentists; students tend to be the youngest, and GDPs together with specialized dentists the oldest. An influence of professional status on restoration performance and longevity has been reported. In two studies among dental students that assessed the performance of composite restorations, annual failure rates were consistent with the results from longitudinal controlled prospective and retrospective clinical trials among GDPs (Manhart et al., 2000, Opdam et al., 2004). In a longitudinal retrospective study in USA where dental students placed extensive restorations and specialized and ordinary dentists were supervisors, survival was better among restorations supervised by specialized dentists than among

restorations supervised by ordinary dentists (49% vs. 32% at 10 years) (Janus et al., 2006). However, in a questionnaire study in USA, specialized dentists' estimates of average longevity of cast and small amalgam restorations were shorter than estimates given by GDPs (Maryniuk and Kaplan, 1986). Again, these differing results might relate to disparities in study settings.

Impact of working sector on restoration longevity has been reported previously. The median age of replaced restorations in adults was significantly shorter with PDS dentists than with private practitioners in a cross-sectional study involving 243 dentists from Norway (Mjör et al., 2000a). This was supported by a cross-sectional study in the UK evaluating placement and replacement of restorations where restorations placed at NHS showed a shorter age at replacement than restorations placed in other sectors (private, insurance, and army) (Burke et al., 2002). On the other hand, a questionnaire study in the USA evaluating restoration longevity estimates revealed that dentists at hospitals and dental schools gave shorter longevity estimates than GDPs (Maryniuk and Kaplan, 1986).

Changing of the dentist may lead to an assumption of shorter restoration longevity in light of the well-established variation in dentists' treatment decisions. Indeed, in the UK and USA, a change of dentist was associated with an increased risk of restorative re-intervention (Bogacki et al., 2002, Burke et al., 2005b). In addition, the higher the number of dentists involved, the higher the risk of amalgam restoration replacement among military personnel in the UK when assessed by a multilevel survival analysis (Gilthorpe et al., 2002). However, in Australia, survival of restorations was longer when the patient changed the dentists in a retrospective study of patient records including 966 replacements of restoration (Mahmood and Smales, 1994). By contrast, a retrospective study involving 20 male private practitioners from Australia found no correlation between restoration longevity and changing of the dentist (Hawthorne and Smales, 1997).

Consistency and properties of the material itself affect clinical outcome of restoration. Development of valid laboratory tests to predict restoration performance is challenging since associations between factors related to both patient and dentist are complicated. However, as evidenced by longitudinal prospective studies, a difference exists in amalgam longevity and survival also depending on the alloy; high-copper amalgams have shown higher longevity than conventional and zinc-free amalgam (Letzel et al., 1989, Jokstad and Mjör, 1991, Smales, 1991), the latter probably having lower corrosion resistance (Letzel et al., 1997). Since the 1980s, an enormous improvement has occurred in composite filler particle size and structure, resulting in fewer clinical challenges of excessive wear, surface roughness, and staining (Sarrett, 2005). However, due to the fast development of tooth-colored materials in particular, no long-term results on longevity have been obtained. In addition, manufacturers' description of ingredients for composites has often been insufficient (Tillberg et al., 2008).

For comparing the performance between different materials, a longitudinal prospective study is preferable, allowing standardized conditions, although studies of various natures have been conducted as well. In a longitudinal study, one dentist placed 330 posterior composites and amalgams in 1986 in Australia; after the 8-year follow-up, composites had failed at a rate two- threefold that of amalgam restorations (Collins et al., 1998). Analysis of insurance claim-based data of over 300 000 patients' posterior teeth revealed that

during an average observation time of 44 months for amalgam and 36 months for composite, amalgam had a lower chance than composites of failure (Bogacki et al., 2002). During 11 years of observation of re-treatment of restorations in GDS of England and Wales based on payment claim forms, the authors concluded that “performance of amalgam restorations didn’t alter significantly with time, but performance of composite and glass ionomer deteriorated with time” (Burke et al., 2005a). In their study, analyzing data of direct restorations with the modified Kaplan-Meier method gave an estimate of 9 years for “median interval for next intervention” (Lucarotti et al., 2005c). In the Netherlands, no significant effect of material on the survival of posterior amalgam or composite restorations was recently observed in general practice in a retrospective study (Opdam et al., 2007), but only two dentists were involved.

Median age of gold restorations (20 years) was longer than that of other materials in a cross-sectional study, including 292 gold restorations in the 1990s; however, evaluation of median ages of various materials should be done with caution since the patient’s clinical situation can limit the use of some materials (Jokstad et al., 1994).

## **2.4 Pain control in restorative treatment**

Modern textbooks on restorative dentistry recommend proper pain management. In ordinary operative procedures, such as drilling, patients should experience only minor discomfort. The American Academy of Pediatric Dentistry (AAPD, 2009) has recently updated the guideline on the use of local anesthesia, focusing mainly on anesthetic substances, interactions, and complications. Painful and invasive dental procedures can be a source of fear of treatment for some patients. However, some patients express high levels of fear with no experience of dental procedures, possibly as the result of learned anxiety from friends or family members. Difficult dental experiences, especially in childhood, can form a barrier to good dental care in adulthood (Milgrom et al., 1995, Rantavuori et al., 2004). Dental fear can to some extent influence the efficacy of local anesthesia (Meechan, 1999, Nakai et al., 2000). From 1992 onwards, Finnish legislation (Ministry of Social Affairs and Health, 1992) has required that patients’ wishes and opinions be taken into account. Today, adults demand pain-free treatment for emergency dental visits (Chanpong et al., 2005) and injection-free local anesthesia during periodontal visits (Matthews et al., 2001). Patients’ demands for pain-free care pose an undeniable challenge for dentists.

### **2.4.1 Use of local anesthesia**

Dentists over the last century have used local anesthesia (Calatayud and Gonzalez, 2003); first for only extractions and later for restorative dentistry as well. Cultural differences exist in the use of local anesthesia. In Asia, 10% of patients reported the use of local anesthesia for tooth drilling, whereas virtually all (94%) American were anesthetized (Moore et al., 1998b). There were no differences by patients’ gender or age on the

preference of local anesthesia for tooth drilling (Moore et al., 1998a), but the questionnaire-based study only included adults. In Asia, the dentist usually decides whether to use local anesthesia, while in USA and Scandinavia, adult patients typically decide for themselves (Moore et al., 1998b). Interestingly, a preference for local anesthesia for tooth drilling was reported by 46% of Scandinavian patients, but when Scandinavian dentists have their own teeth drilled, 93% preferred local anesthesia (Moore et al., 1998b). A study of pain management for children's restorative treatment reported that American dentists were more likely than Finnish dentists to use local anesthesia when restoring primary or permanent teeth (Murtomaa et al., 1996).

Administration of local anesthesia can be distressing for patients. A recent RCT compared two different local anesthesia methods in children; the level of dental anxiety influenced pain behavior and distress during administration of local anesthesia, but no difference was found between the methods used (Versloot et al., 2008). Dentists may avoid using local anesthesia altogether. Inferior alveolar injection and injections for preschool children have been identified as sources of stress for dentists and may affect a small proportion of practitioners both psychologically and physically (Simon et al., 1994, Dower et al., 1995, Rasmussen et al., 2005).

Previous research has shown that the use of local anesthesia can increase the longevity of restoration in children (Walls et al., 1985). However, a study among children in Surinam failed to confirm this (Van de Hoef and Van Amerongen, 2007). Undesirable results in children were reported in Wales, where only 68% of dentists stated that they always use local anesthesia when performing pulpotomy in a vital primary teeth (Hingston et al., 2007).

Dentists' gender, experience, and working sector may influence the decision to use local anesthesia in restorative treatment, but dental literature on this topic is sparse. A questionnaire study among dentists from USA, Scandinavia, and Asia found no differences by dentists' gender or age on the preference of local anesthesia for their own tooth drilling (Moore et al., 1998a). In Denmark, however, female dentists reported using topical analgesia prior to injection more frequently than male dentists (Rasmussen et al., 2005). In the UK, a study among dental students noted a gender difference in the attitude towards local anesthesia; females were more anxious about giving and receiving injections than males (Meechan, 2005a). In USA, the use of local anesthesia for children was related significantly more to private practice dentists than dentists at non-profit clinics when responses to a questionnaire were analyzed with a logistic regression model (Milgrom et al., 1994). No previous studies exist regarding the influence of other dentist-related factors than nationality on the use of local anesthesia in restorative treatment in Finland.

## **2.5 Current knowledge of restorative modalities**

The findings of studies evaluating the reasons for placement of restoration have remained relatively unchanged during the past 20 years. Primary caries and replacements have predominated, with secondary caries and fractures dominating as reasons for replacement



similarly for all materials. These findings reflect the slow nature of changes in restorative treatment practices, and more importantly, the absence of a definitive cure for caries.

Regarding the use of restorative materials, rapid changes have occurred in the 1990s; dentists have easily adapted new techniques, including materials, and Finland has moved to the post-amalgam era along with other Nordic countries. New knowledge, teachings at dental schools, recommendations by relevant authorities, legislation, and patients' opinions influence dentists' attitudes towards restorative materials. Other influential factors may remain to be uncovered. Such influences seem to vary depending on the country in question, the care provision system, the quality of the debate in the media, and the personal views and preferences of both dentists and patients. According to cross-sectional studies, dentists' gender and experience do not influence material selection, while working sector does; dentists in the public sector use amalgam more frequently than their colleagues in the private sector. However, in questionnaire studies, dentists' gender, experience, and working sector seem to have only a marginal impact: females and more experienced dentists are slightly more positive towards amalgam than males or younger dentists. Private dentists, as compared with PDS dentists, favor indirect restorations and seeking the patient's opinion.

The determination of restoration longevity has many barriers to cross. First, a wide range of research methods has been used. Second, the terminology is confusing. Third, the factors affecting longevity are numerous. Despite these difficulties, the longevity of restorations has been studied extensively, and the numerous study methods and miscellaneous statistical analyses complicate the final definition of longevity. In addition, a number of patient- and dentist-related factors as well as environmental aspects affect longevity, further complicating this determination. Differences in study settings, such as RCT or cross-sectional studies, may explain the conflicting results, but these methods can also be complementary. It can be concluded, though, that restoration longevity obtained in special circumstances is higher than in "real life" and is higher for posterior amalgam than for composite. Moreover, restoration longevity is shorter and replacement rate higher among patients belonging to the high-caries risk group or having a large number of previous restorations. In light of the current studies regarding dentist-related factors and variation in restorative practices, it is questionable whether valid conclusions can be drawn from studies involving only two or three dentists since these studies hardly cover the variation in treatment practices. However, previous research does suggest that more experienced dentists and dentists working in the private sector have lower replacement rates and achieve higher restoration longevity than less experienced dentists and those in the public sector.

There are currently no guidelines on the use of local anesthesia for restorative treatment. The influence of dentist- and patient-related factors on use of local anesthesia in restorative treatment has been studied rarely, but cultural differences are evident; in Nordic countries, one in every two adults prefers local anesthesia for restorative treatment.

### 3 AIMS OF THE STUDY

The general aims of the study were to assess aspects of restorative treatment in the Public Dental Service and evaluate variation in restorative treatment practices among Finnish dentists.

More specifically, the aims were as follows:

1. to assess reasons for placement and replacement of restoration (**I, II**)
2. to assess material selection for direct restorations (**I**)
3. to assess actual restoration longevity and dentists' estimates of longevity (**II, III**)
4. to assess the use of local anesthesia in restorative treatment (**I, IV**)
5. to evaluate the impact of dentist-related factors on restorative treatment practices (**I, II, III, IV**)

The following working hypotheses were formulated:

1. Dentist-related factors have no impact on variation in reasons for placement and replacement, on material selection, or on the use of local anesthetics.
2. The use of local anesthetics does not vary according to patients' age.

## 4 SUBJECTS AND METHODS

### 4.1 Description of the dental service system in Finland

Two parallel systems currently exist for dental services in Finland: public and private. The majority of the public sector consists of the municipal Public Dental Service (PDS); in addition, universities, public hospitals, the Finnish Student Health Service, and the Army belong to the public sector, all employing both general dental practitioners (GDPs) and specialized practitioners. In the private sector, GDPs and specialized practitioners work as independent practitioners, mostly in private dental clinics. Dentists in both sectors are obliged to keep detailed records of every visit, today comprising mostly electronic patient files using standardized codes for diagnoses and treatments. In 2008, of all dentists in Finland, 25% were aged 25-41 years, 69% were women and over 50% worked in the public sector.

The PDS in Finland has a history of sporadic dental treatments from the beginning of the 20th century for schoolchildren, but not for children under school age. From 1957 onwards, school dental care regulations have obliged municipalities to provide dental services, including treatment and preventive measures, to all pupils at public schools: children below school age were still not included. Restorations of primary teeth were uncommon. Finally, the Primary Health Care Act in 1972 (Ministry of Social Affairs and Health, 1972) ensured that all children were covered by PDS.

Taxation, governmental subsidies, and patient fees finance the PDS. The PDS treatment strategy is the same throughout the country, including work under unified instructions, use of standardized dental records, and similar policies of comprehensive dental care. Dentists receive a fixed monthly salary and supplementary payments according to the clinical procedures performed on patients.

Almost all parents choose PDS for their children (Nordblad et al., 2004). By law, free-of-charge dental care is extended to children aged 0-17 years (until the year 2002, children aged 0-18 years) but adults have to pay fees, albeit highly subsidized, for their dental procedures. Municipalities can enlarge the age limits and provide free-of-charge care to a larger entity than the law mandates. Until December 2002, resource deficiency allowed restrictions on adults in PDS. Thereafter, discrimination by age is not allowed, leading to a waiting list system for adults, e.g. in the Helsinki PDS. Since 2003, adults are also entitled to all dental treatments if medically inevitable, including prosthetics and orthodontics.

Private dental services are open to everyone, but adults form the majority of patients. At the beginning of the 21st century, the private sector provided more than half of all adult dental care (Statistical Yearbook of Finland, 2004). The majority of private sector dentists work as solo practitioners. Patients are charged on a per item basis. Until 2002, patients born in 1956 or after received partial reimbursement of costs from the Social Insurance Institution (KELA) of Finland. Since 2002, everyone has been entitled to partial reimbursements. However, fees at private clinics are about twice as high as PDS fees even after KELA reimbursement. In addition, prosthetics and orthodontics are not covered.

Women and individuals with a higher income characterize the patient flow at private clinics (Arinen et al., 1998).

## **4.2 Study subjects**

Study subjects ascertained from three different sources were recruited to evaluate restorative treatment practices in Finland. Study I assessed routine restorative treatment provided at the Helsinki PDS. Young adults' patient records from the Vantaa PDS served as the basis for assessment of replacement of restoration for Study II. In addition, a postal questionnaire to GDPs inquiring about their restorative treatment practices for adults was the basis for Studies III and IV.

### **Sample 1 (I)**

This sample came from the Helsinki City Health Centre. Helsinki is the capital of Finland, with over 550 000 residents. Services of the Helsinki PDS in 2001 were available to residents aged under 36 years and to some specific groups above this age, i.e. pregnant women, mentally handicapped patients, referrals by physicians, and war veterans. Some 140 000 patients were treated at 56 dental clinics by 169 dentists.

This cross-sectional study was aimed at all GDPs (n=140) working in Helsinki PDS; orthodontists and dental surgeons were therefore excluded. The 2001 data were derived from the pre-designed forms that Helsinki PDS dentists completed during a fixed 2-week period of routine clinical work.

### **Sample 2 (II)**

This sample was derived from the Vantaa PDS, which belongs to the metropolitan area. In 1995, Vantaa had 165 000 residents, 35% of whom used the PDS services. Adults aged 19-40 years were entitled to subsidized dental care and comprised one-third of the visits. There were 37 clinics and 64 dentists working at the Vantaa PDS in 1995.

The target population consisted of all patients born from 1966 to 1971 who were clinically examined in 1994 (n=3248) at the Vantaa PDS. Sampling comprised 4-5 cases per dentist; these were randomly selected from each dentist's patient list, resulting in 239 patients (Helminen, 2000). Oral health documents that included a completed treatment course between 1994 and 1996 were available for 208 patients (87%). Due to the focus of this study, only patients with at least one posterior restoration were included (n=205).

### **Sample 3 (III, IV)**

This sample was aimed at general dental practitioners (GDPs) in Finland. There was a total of 4387 working-aged dentists in Finland in 2004 - 60% in the PDS - 69% were female. The sample (n=592) was drawn by means of systematic sampling from the membership list of the Finnish Dental Association, which included 98% of all dentists in the country. Sampling excluded all specialized practitioners, such as oral surgeons and

orthodontists, and those above the official retirement age of 65. The 2004 data were derived by a questionnaire inquiring about aspects of dentists' restorative treatment practices for adults.

## **4.3 Study design and data collection**

### **Sample 1**

#### Study design

A self-administered and pre-designed form was pre-tested by four dentists in the Helsinki PDS. After amendments, the final version (original form available upon request from the author), accompanied by a letter to motivate and instruct signed by the researcher and the chief dental officer (CDO) of the Helsinki PDS, was delivered in May 2001 to all GDPs working for the Helsinki PDS. Each dentist was requested to complete details on 25 consecutively placed restorations during a fixed 2-week period (weeks 19 and 20) in 2001. Dentists returned completed forms immediately to the CDO's office, and the pre-determined working code of each dentist was subsequently added to the form.

#### Information collected

For each restoration, dentists recorded the patient's gender and year of birth. In addition, details of the restoration by tooth and surfaces, reason for placement or replacement, material used, and use of local anesthetics were recorded. The data completed on pre-designed forms were later stored in electronic databases with a running number for each restoration.

Alternatives given for recording of reasons for placement of restoration were (1) primary caries, (2) replacement of restoration, (3) changing temporary restoration to permanent one, and (4) other, e.g. trauma, fracture of tooth, erosion, or abrasion. In addition, alternatives given for reasons for replacement of restoration were (1) secondary caries, (2) fractured or lost restoration, (3) marginal ridge discrepancy or poor anatomic form, (4) discoloration or patient's request, (5) erosion or abrasion, and (6) caries on another surface. No further description of options was available, nor were dentists calibrated in caries diagnosis or in criteria for replacements.

The public authorities of the Helsinki City Health Centre supplied dentists' background data, such as gender and year of birth, based on the pre-determined working code of the dentist in question, and these were subsequently added to the data for this study.

#### Study subjects and backgrounds

In total, 137 dentists (98%) returned the completed forms: 85% of these dentists were female. Dentists' age range was 25-63 (mean 41.6, SD 9.4, median 41) years (Table 4.1). Three dentists were excluded from the analysis, having recorded fewer than five restorations due to an absence from work during the fixed 2-week period.

Patients' age range was 2-91 (mean 26.3, SD 15.1) years; 56% were female, and 39% received free-of-charge care. The mean age of patients treated by female dentists was 26.4 (SD 15.1) years, and by male dentists 27.0 (SD 14.7) years. The mean age of patients treated by dentists aged under 35 years was 27.0 (SD 14.4) years, by dentists aged 35-39 years 25.9 (SD 14.4) years, by dentists aged 40-45 years 28.4 (SD 15.6) years, and by dentists aged 45 and older 24.7 (SD 15.1) years.

## **Sample 2**

### Study design

The cross-sectional data of posterior restorations of the Vantaa PDS were collected from individual patient records in paper format. Information of the most recent completed treatment course, including history of replaced posterior restorations, was recorded in 1996 by the author on data collection forms by a running number for each patient, and later stored in electronic databases.

### Information collected

For each patient, the data included gender, date of birth, date of visit, and latest dental status recorded by surface and by tooth. DMFT and DMFS indices were calculated from dental status recordings. Details of each initial restoration in premolars and molars included material, location, and surface coverage of the restorations. Types of restoration were categorized according to Black and grouped into Class I, Class II, and separately into MOD. Restorations with buccal or mesial surface involvement were recorded as visible.

For each replacement of restoration in premolars or molars, the dates of initial restoration and replacement and the use of local anesthesia were retrospectively collected. The age of a failed restoration was screened within one-month accuracy from patient records. In case the exact date was not found in patient records, the first appearance of the restoration in question was taken as the approximate date of initial restoration. Such estimation was necessary for 25% of restorations.

Options for coding reasons for replacement of restoration retrieved from patient records were (1) secondary caries, (2) open margin, marginal ridge discrepancy, (3) filling or tooth fracture, (4) poor anatomical form, (5) overhangs, (6) discoloration, (7) patient's request/poor esthetics, and (8) caries on another surface, involving removal of the existing restoration.

The public authorities of the City of Vantaa supplied dentists' background data, such as gender, year of graduation, and year of birth, based on pre-determined working codes, and these were subsequently added to the data for this study.

### Study subjects and backgrounds

In this study, 51 dentists participated, 86% being female. Dentists' year of graduation ranged from 1958 to 1995, and ages ranged from 30.3 to 62.3 years (mean 43.1, SD 7.5, median 40.6) (Table 4.1). The number of patients was 205; 66% were female. Patients' ages ranged from 22.3 to 30.4 years (mean 26.7, SD 2.0, median 26.8).

### **Sample 3**

#### Study design

A self-administered two-page questionnaire was pre-tested by six GDPs and revised to obtain the final version. The questionnaire and a cover letter signed by the researchers were sent with a pre-paid reply envelope to the sampled Finnish GDPs in April 2004, followed by one reminder with a deadline by the end of June.

#### Questionnaire

Questions inquired about dentists' restorative practices regarding adults. This study evaluated aspects of restorative practices with two questions.

#### **Question on the use of local anesthesia**

*"How often do you use local anesthesia when restoring vital teeth in adults?"*

- Case 1. For Class III primary restoration in an incisor
- Case 2. For Class II restoration in a premolar or molar
- Case 3. For Class V restoration on gingival margin in a premolar or molar

Responses were given on a four-point scale: (a) always or almost always, (b) fairly often, (c) occasionally, and (d) rarely or never. For the primary analysis, these were combined into two categories for description of data: "often" (a and b) and "seldom" (c and d). For further analysis, the original responses from a to d were given the scores 0, 1, 2, and 3; the sum of these scores determined the dentist's interest in the use of local anesthesia.

#### **Question on perception of restoration longevity**

*"In general, what is your estimate of the mean age of direct restorations of the following types in permanent teeth?"*

- Case 1. Two-surface amalgam restoration in a posterior tooth
- Case 2. Two-surface composite restoration in a posterior tooth
- Case 3. Three-surface (MOD) amalgam restoration in a posterior tooth
- Case 4. Three-surface (MOD) composite restoration in a posterior tooth
- Case 5. Class III composite restoration in an incisor tooth

Responses to these open-ended questions were given in years.

### *Questions on dentist-related factors*

Questions on demographic background inquired about a dentist's gender, main work, and year of graduation. For the latter, the alternatives included 1960-1977, 1978-1987, 1988-1997, and 1998-2003. In the analyses, these were combined into three categories of time since graduation: 1-16 years, 17-26 years, and over 26 years. The question about the main work had four response alternatives: public, private, hospital or university, and other. The analyses of restoration longevity covered only public and private dentists. For the analyses regarding the use of local anesthesia, the original four response alternatives were reclassified into two groups: the first category "public" included hospital, university, or other, and the second category was "private".

### Response rate and respondents' background

In total, 339 dentists (57%) returned the questionnaire; 71% were women and 61% worked in the public sector (including hospitals and other). Of all dentists, 31% had graduated less than 16 years ago, 44% 17-26 years ago, and 25% more than 26 years ago.

**Table 4.1** *Characteristics of the three samples*

Sample, place, time of data collection	Type of data	Patients n	Patient age years (mean)	Dentists n	Dentist age years (mean)	Restorations n
Sample 1 Helsinki PDS 2001	Pre-designed form completed during clinical work	n.a.	2-91 (26.3)	137	25-63 (41.6)	3057
Sample 2 Vantaa PDS 1996	Patient record in paper format	205	22.3-30.4 (26.7)	51	30.3-62.3 (43.1)	1969
Sample 3 Finland 2004	Postal questionnaire	-	-	339	n.a.	-

n.a. = not available

## **4.4 Statistical analyses**

The statistical significance of differences in frequencies between the compared groups was tested by means of the Chi-square test. One-way ANOVA served for evaluation of the mean values between subgroups. The level of significance was set at  $p=0.05$  throughout the study.

For dentists' longevity estimates, descriptive statistics included means, standard deviations (SDs), and 95% confidence intervals (95% CIs) of the means.

Evaluation of the use of local anesthesia in relation to dentist-related factors was performed by means of logistic a regression model. Odds ratios (ORs) were first defined as cross-products for the "at least fairly often" use of local anesthesia. Explanations for the "always or almost always" use of local anesthesia included dentist-related factors together in a logistic regression model that simultaneously controlled for all factors in the model. A 95% CI was calculated for each OR.



## 5 RESULTS

### 5.1 Treatment practices (I, II, III)

#### 5.1.1 Reasons for placement of restorations in Public Dental Service (PDS) in 2001 (I)

In 2001 the Helsinki Public Dental Service (PDS) information covered placement of a total of 3057 restorations; 17% were placed in incisors, 17% in premolars, 52% in molars, and 14% in primary teeth (I). Primary caries was the main reason (59%) for placement of restorations (Table 5.1). In patients under 20 years of age, it was the reason for 85% of restorations. One of three of restorative treatments was a replacement of restoration: among patients over 36 years, it represented the majority (61%). Other reasons (trauma, erosion, abrasion, and temporary restoration to a permanent one) for initial restoration comprised 9% of all restorations.

**Table 5.1.** *Distribution (%) of restorations (n=3057) by reason for restoration according to patient age in the PDS in 2001.*

Reason for restoration	Patient age <sup>1)</sup>				All n=3057 %
	<13 years n=643 %	13-19 years n=543 %	20-36 years n=1147 %	>36 years n=724 %	
Primary caries	85	85	51	28	59
Replacement	10	9	38	61	32
Other	5	6	11	11	9

p<0.001

Statistical evaluation by Chi-square test

1) <20 years = free-of-charge care, 20+ years = subsidized care

#### 5.1.2 Reasons for replacement of restoration in PDS in 1994-1996 and 2001 (I, II)

##### PDS in 2001 (I)

A total of 982 replacements of restoration were placed; 22% in premolars, 54% in molars, and 5% in primary teeth. The material of restoration to be replaced was amalgam for 36%, composite for 53%, and GI and its derivatives (GIs) for 11%. The main reasons for replacement of restoration were secondary caries (41%) and fractures of teeth or restorations (40%). Fractures were most frequent in molars (53%), followed by incisors (22%) and premolars (18%). The reason for replacement in primary teeth was fracture in 60% and secondary caries in 29% of cases. Secondary caries was the reason for replacement more frequently for amalgam restorations (52%) than for composites (37%) or GIs (40%) (Table 5.2). For tooth-colored restorations, fractures were the main reason

for replacement of composites (45%) and secondary caries for replacement of GIs (40%). For all materials, esthetics and other reasons were rare.

**Table 5.2** *Distribution (%) of reasons for replacement of amalgam and tooth-colored restorations (n=982) in the PDS in 2001.*

Reason for replacement	Amalgam n=298 %	Composite n=435 %	GIs <sup>1)</sup> n=87 %
Secondary caries	52	37	40
Fractures	27	45	38
Caries on adjacent surface	10	3	5
Poor anatomical form	10	11	12
Esthetics/Other	1	4	5
		p<0.001	

Statistical evaluation by Chi-square test

The reason for 18 restorations and the initial material for 144 re-restorations are missing

1) Glass-ionomer and its derivatives

### PDS in 1994-1996 (II)

The mean number of posterior restorations was 9.6; 86% were amalgam. A total of 140 replacements were made; 84% were amalgam and 74% were located in molars (II). The main reasons for replacement of restoration were fractures (47%) and secondary caries (31%). The more restorations patient had, the more replacements were performed (Fig. 5.1). The replacement rate for all existing posterior restorations was 7%, tending to be slightly higher for tooth-colored than amalgam restorations.

## **5.1.3 Choice of restorative materials in PDS in 1994-1996 and 2001 (I, II)**

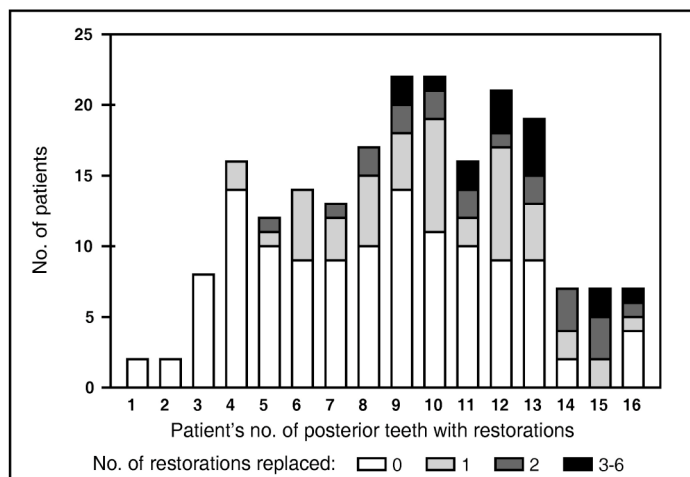
### PDS in 2001 (I)

Of all materials used, 69% were composite, 21% GIs, and 5% amalgam (Table 5.3). The majority of all restorations placed were composites in patients aged over 12 years; in patients under 13 years GIs dominated. Amalgam was used more frequently for older patients, comprising 10% of restorations placed among patients over 36 years of age. Temporary material comprised 5% of all restorations and was used more frequently for patients 20-35 years than for other age groups.

In permanent teeth, the dominant material was composite (80%), followed by GIs (10%), amalgam (6%), and temporary material (4%). For molars, the corresponding figures were 74%, 12%, 8%, and 6%, and for premolars, 86%, 7%, 3%, and 4%. For primary teeth, GIs were the predominant material (88%), and amalgam was not used at all. In 57% of restoration replacements the material stayed the same. Of amalgams 65% changed to composite, and of composites, 3% changed to amalgam.

### PDS in 1994-1996 (II)

Regarding replacement of posterior restoration, the material changed in 50% of cases from amalgam to tooth-colored, and in 18% of cases, vice versa.



**Figure 5.1** Number of replacement restorations in patients (n=205) aged 22-30 years according to the number of posterior teeth with restorations in the PDS in 1994-1996.

**Table 5.3** Distribution (%) of restorations (n=3057) by restoration material and according to patient age in the PDS in 2001.

Material <sup>1)</sup>	Patient age <sup>2)</sup>				All n=3057 %
	<13 years n=643 %	13-19 years n=543 %	20-36 years n=1147 %	>36 years n=724 %	
Composite	28	84	82	75	69
Gls <sup>3)</sup>	68	12	6	11	21
Amalgam	0	1	6	10	5
Temporary	4	3	6	4	5

p<0.001

Statistical evaluation by Chi-square test

1) data missing for 61 restorations

2) <20 years = free-of-charge care, 20+ years = subsidized care

3) Glass-ionomer and its derivatives

### **5.1.4 Use of local anesthesia (I, III)**

#### PDS in 2001 (I)

For restorative treatment, dentists used local anesthesia in 48% of cases, more frequently for older patients (55%) than for patients aged under 13 years (35%) (Table 5.4). For a restoration in an incisor, dentists used local anesthesia in 34% of cases. For premolar or molar restoration, local anesthesia was used for 53%. In primary teeth, local anesthesia was used for 31%.

**Table 5.4** Proportions of restorations (n=3057) placed under the use of local anesthesia according to patient age in the PDS in 2001.

Local anesthesia <sup>1)</sup>	Patient age <sup>2)</sup>				All n=3057 %
	<13 years n=643 %	13-19 years n=543 %	20-36 years n=1147 %	>36 years n=724 %	
Used	35	52	58	38	48
Not used	65	48	42	62	52

p<0.001

Statistical evaluation by Chi-square test

1) data missing for 71 restorations

2) <20 years = free-of-charge care, 20+ years = subsidized care

### Dentists' self-reported use of local anesthesia (III)

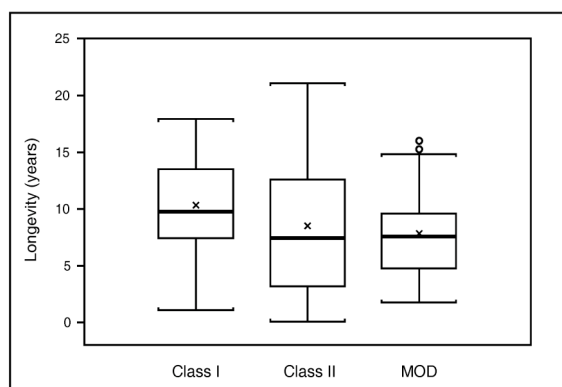
For Class III restoration in anterior tooth, 21% of dentists reported using local anesthesia “always or almost always” and 47% “fairly often”. For Class II restoration in a premolar or molar, 25% of dentists reported using local anesthesia “always or almost always” and 58% “fairly often”. For Class V restoration on the gingival margin in premolars or molars, 22% of dentists described using local anesthesia “always or almost always” and 50 % “fairly often”.

## 5.2 Longevity of restorations (II, IV)

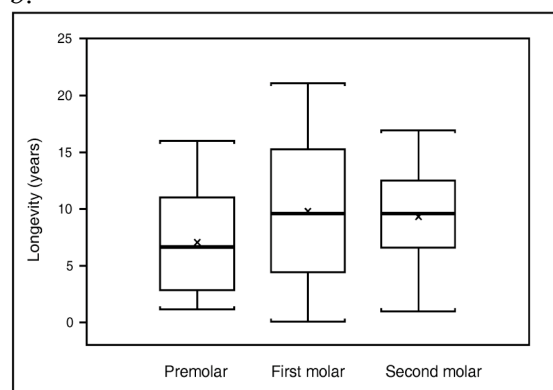
### PDS in 1994-1996 (II)

The history of 140 replacements of restoration among 205 patients aged 22-30 years was scrutinized. The mean age of patients at the time of placement of the initial restoration was 19.0 (SD 5.4, range 7-27) years. The mean age of replaced posterior restoration was 8.9 (SD 5.2) years for amalgam (Table 5.5) and 2.4 (SD 1.4) years for tooth-colored restorations. The mean age of Class I restorations was 10.3 years and of MOD restorations 7.8 years.

a.



b.



**Figures 5.2** Longevity (years) of replaced posterior amalgam restorations (n=117) in patients aged 22-30 years according to category of restoration (a) and type of tooth (b) in the PDS in 1994-1996. In the box-plot, bold line = median, x = mean, boxes and whiskers = quartiles, circles = outliers.

Class I amalgam restorations had a higher median age than Class II or MOD amalgam restorations (Fig. 5.2a). Amalgam restorations in premolars had lower median ages than amalgam restorations in first and second molars (Fig. 5.2b).

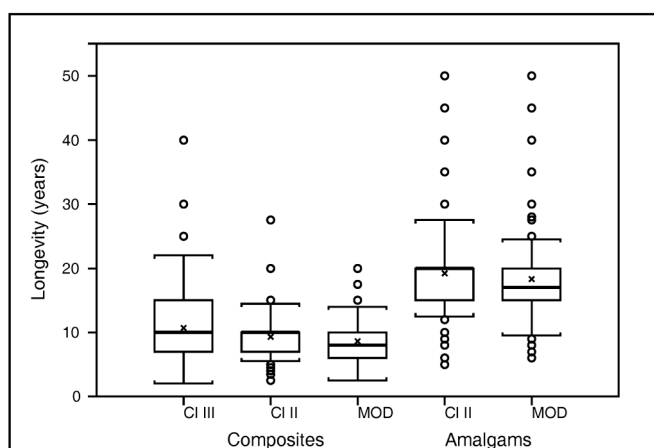
**Table 5.5** Longevity (years) of replaced posterior amalgam restorations (n=117) among patients aged 22-30 years according to characteristics of restorations in the PDS in 1994-1996.

Characteristics of restoration		Longevity Mean (SD)
All		8.9 (5.2)
Type of tooth	Premolar	7.1 (4.6)*
	Molar	9.6 (5.2)
Category	Class I	10.3 (4.7)
	Class II	8.5 (5.5)
	MOD or larger	7.8 (4.3)
Local anesthesia	LA used	7.2 (4.7)
	LA not used	10.8 (4.6)***
Patients' age at restoration		
	≤15 years	14.4 (3.2)***
	>15 years	6.4 (3.8)

Statistical evaluation by ANOVA, \*p<0.05; \*\*\*p<0.001; all others NS

#### Dentists' perception of restoration longevity (IV)

Overall, dentists' mean estimates of restoration longevity were 18.8 (SD 7.3) years for amalgam and 9.0 (SD 3.6) years for posterior composite (Fig. 5.3). Dentists' estimates displayed a wide range, especially for amalgam restorations, and the medians were near the mean longevity estimates.



**Figure 5.3** Longevity estimates (years) for different categories of composites and amalgams based on survey of Finnish dentists (n = 328) in 2004. In the box-plot, bold line = median, x = mean, boxes and whiskers = quartiles, circles = outliers. Reprinted from *Acta Odontol Scand*, Vol 67, Palotie and Vehkalahti, Finnish dentists' perceptions of the longevity of direct dental restorations, pages 44-49, Copyright 2009 - with permission from Taylor & Francis.

### 5.3 Dentist-related factors regarding variation in restorative treatment practices (I, II, III, IV)

#### Gender

##### PDS in 2001 (I)

Overall, no gender difference was present in reasons for restoration placement ( $p=0.44$ ), material selection regarding anterior teeth ( $p=0.49$ ) or posterior teeth ( $p=0.09$ ), use of local anesthesia ( $p=0.84$ ) for primary restoration (Tables 5.6-5.8). Among reasons for replacement, secondary caries was named more frequently and fracture less frequently by male dentists than by female dentists ( $p=0.03$ ) (Table 5.7).

**Table 5.6** Distributions (%) of composite, glass-ionomer and its derivatives (GIs), and amalgam restorations placed by type of permanent tooth ( $n=2565$ ) according to dentists' gender and age in the PDS in 2001.

Type of tooth and restoration material	Dentist's gender		Dentist's age (years)			
	Men	Women	<35	35-39	40-44	45+
Anterior teeth	n=66 %	n=434 %	n=108 %	n=74 %	n=162 %	n=156 %
Composite	89	92	94	93	92	89
GIs	11	8	6	7	8	11
	p=0.49		p=0.33			
Posterior teeth	n=335 %	n=1611 %	n=493 %	n=379 %	n=494 %	n=580 %
Composite	80	82	83	77	84	81
GIs	10	11	10	15	9	12
Amalgam	10	7	7	8	7	7
	p=0.09		p=0.10			

Statistical evaluation by Chi-square test.

**Table 5.7** Distributions (%) of reasons for placement (n=3057) and replacement of restorations (n=982) according to dentists' gender and age in the PDS in 2001.

Placement of restorations by reason	Dentist's gender		Dentist's age (years)			
	Men	Women	<35	35-39	40-44	45+
All restorations (n=3057)	n=473 %	n=2584 %	n=734 %	n=571 %	n=821 %	n=931 %
Primary caries	57	59	57	55	57	64
Replacement	32	32	31	35	35	29
Other	11	9	12	10	8	7
	p=0.44		p<0.001			
Replacements only (n=982) <sup>1)</sup>	n=150 %	n=814 %	n=221 %	n=194 %	n=286 %	n=263 %
Secondary caries	51	39	47	43	39	36
Fractured or lost	34	41	38	46	38	40
Other	15	20	15	11	23	24
	p=0.03		p<0.002			

Statistical evaluation by Chi-square test.

1) data missing for 18 restorations

**Table 5.8** Distributions (%) of primary restorations (n=1798) according to use of local anesthesia (LA) by type of tooth and according to dentists' gender and age in the PDS in 2001.

Type of tooth	Dentist's gender		Dentist's age (years)			
	Men	Women	<35	35-39	40-44	45+
All teeth	n=271 %	n=1527 %	n=421 %	n=316 %	n=464 %	n=597 %
LA used	52	52	57	56	55	45
LA not used	48	48	43	44	45	55
	p=0.84		p<0.001			
Primary teeth	n=59 %	n=312 %	n=74 %	n=75 %	n=91 %	n=131 %
LA used	36	31	39	41	35	21
LA not used	64	69	61	59	65	79
	p=0.53		p=0.005			
Incisors	n=31 %	n=223 %	n=63 %	n=35 %	n=75 %	n=81 %
LA used	42	49	52	51	52	41
LA not used	58	51	48	49	48	59
	p=0.44		p=0.42			
Premolars and molars	n=181 %	n=992 %	n=284 %	n=206 %	n=298 %	n=385 %
LA used	59	60	62	62	61	54
LA not used	41	40	38	38	39	46
	p=0.80		p=0.10			

Statistical evaluation by Chi-square test.

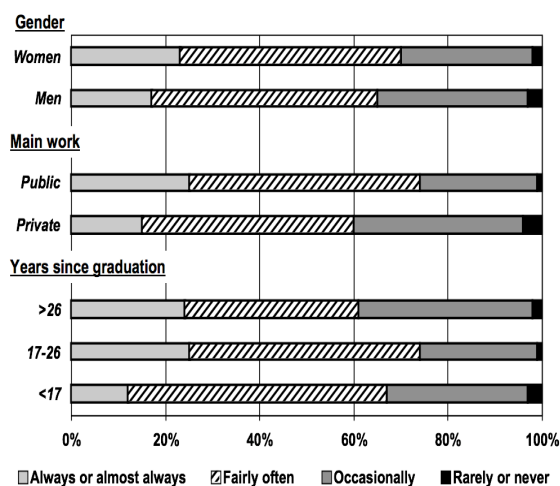
### PDS in 1994-1996 (II)

Replacement rate of posterior restorations was higher among female dentists than among male dentists ( $p=0.01$ ), especially for amalgam ( $p=0.008$ ) (Table 5.9). Female dentists' replacement rate of molar amalgams was higher than that of male dentists ( $p=0.03$ ).

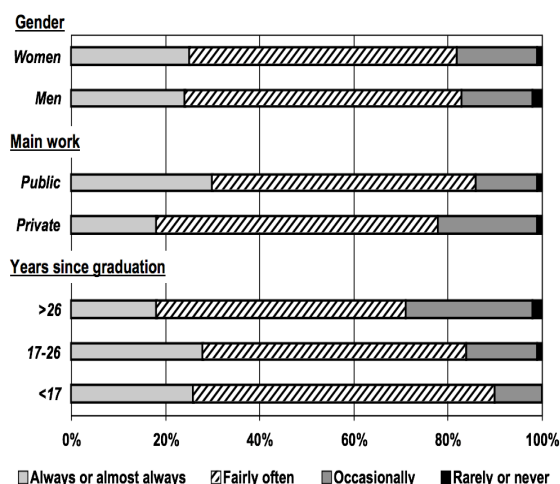
### Dentists' own reports (III, IV)

No gender difference emerged in self-reported use of local anesthesia (Figs. 5.4). Female dentists had longer estimates of amalgam longevity than male dentists ( $p<0.001$ ) (Table 5.10).

**Figures 5.4** Self-reported (%) use of local anesthesia for adults obtained from a survey of Finnish dentists in 2004 ( $n=339$ ) for three separate cases.

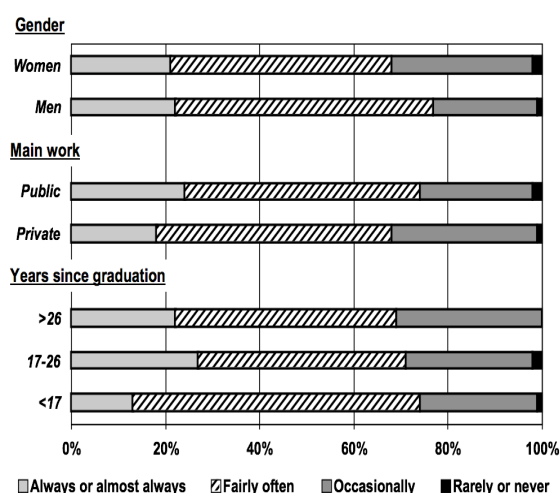


*Case 1. Class III primary restoration in incisors.*



*Case 2. Class II restoration in premolars or molars.*





Case 3. Class V restoration on the gingival margin of premolars or molars.

**Table 5.9** Proportions of replacements among 1969 posterior restorations in patients aged 22-30 years by material of initial restoration and according to dentists' characteristics in the PDS in 1994-1996.

Dentists' characteristics		Material of initial restoration		
		Amalgam n=1699 % replaced	Tooth colored n=270 % replaced	All n=1969 % replaced
All		6.9	8.5	7.1
Gender	Male	3.2	8.1	3.8
	Female	7.6*	8.6	7.6**
Year of graduation				
	Before 1980	5.8	8.3	6.1
	1980 or later	7.9	8.7	8.0

Statistical evaluation by Chi-square test, \*p=0.008; \*\*p=0.01; all others NS

## Professional experience

### PDS in 2001 (I)

Overall, regarding material selection, no differences existed between dentists' age groups (Table 5.6). Primary caries was the reason for placement of restoration more frequently among dentists 45 years of age and older than among other ages (Table 5.7). Replacements of restorations were made by younger dentists more frequently than by older dentists ( $p<0.001$ ). Secondary caries was the reason for replacement more frequently among younger dentists than among older dentists, and dentists aged 35-39 years cited fractured or lost as the reason more frequently than other ages ( $p<0.002$ ). Older dentists less often used local anesthesia for primary restoration than younger dentists ( $p<0.001$ ), especially in primary teeth ( $p=0.005$ ) (Table 5.8).

### PDS in 1994-1996 (II)

Dentists with more years since graduation had a lower replacement rate of posterior amalgam restorations than dentists with fewer years since graduation, the difference being nonsignificant (Table 5.9).

### Dentists' own reports (III, IV)

Dentists with fewer years since graduation stated more frequently ( $p=0.03$ ) than dentists with more years since graduation that they “always or almost always” use local anesthesia for Class II restoration (Figs. 5.4). For Class III restoration in anterior tooth longer time since graduation was strongly related to dentists’ “always or almost always” self-reported use of local anesthesia ( $OR=1.5$ ,  $p=0.02$ ). Dentists with more years since graduation had higher longevity estimates for anterior composites than other dentists (Table 5.10).

**Table 5.10** *Finnish dentists' (n=328) perception of restoration longevity (years) in 2004. The longevity estimates for restorations of posterior composite and amalgam and anterior composite are according to dentists' gender, working sector, and years since graduation.*

Gender		Posterior amalgam	Posterior composite	Anterior composite
		Mean (SD)	Mean (SD)	Mean (SD)
	Men	16.7 (6.0)	9.7 (3.9)	11.2 (6.0)
	Women	19.6 (7.7)	8.7 (3.4)	10.5 (4.9)
		$p<0.001$	$p=0.04$	$p=0.34$
Working sector	Public	19.2 (7.6)	8.4 (3.1)	10.4 (4.9)
	Private	18.2 (6.9)	9.8 (4.1)	11.2 (5.6)
		$p=0.21$	$p=0.001$	$p=0.18$
Years since graduation	>26	20.3 (8.1)	9.1 (3.0)	11.9 (6.3)
	17-26	18.1 (7.7)	9.0 (4.0)	10.6 (4.8)
	1-16	18.6 (5.8)	8.9 (3.4)	9.9 (4.6)
		$p=0.09$	$p=0.86$	$p=0.05$

Statistical evaluation by ANOVA.

### **Working sector**

#### Dentists' own reports (III, IV)

Public sector dentists reported using local anesthesia more frequently than private dentists for Class II ( $p=0.04$ ) and Class III restorations ( $p=0.01$ ) (Figs. 5.4). For Class V restorations, no significant difference was seen. Private dentists had longer estimates of posterior composite longevity than PDS dentists ( $p=0.001$ ) (Table 5.10).

## 6 DISCUSSION

### 6.1 Methodological aspects

#### Sample 1

##### Subjects

Study I evaluated aspects of restorative treatment in the Public Dental Service (PDS). The observation units were individual restorations. By gender and age, patients receiving restorative treatment represented normal patient flow in the PDS. Data collection took place in May, outside the official holiday season, implying ordinary patient visits, including schoolchildren.

Regarding assessment of dentist-related factors, information covered practically all targeted Helsinki PDS dentists; thus, the monitoring focused on real-life situations where dentists treated patients and filled out patient records as part of their daily routines. The majority of dentists evaluated were female, consistent with gender proportions in the PDS everywhere (Finnish Dental Association, 2004). Since the Helsinki PDS has had a resource deficiency, the mean age of treated patients has been lower than in other parts of Finland, and many of the adult patients have belonged to some privileged group (pregnant women, mentally handicapped patients, referrals by physicians, and war veterans). However, due to the large coverage and utilization rate of PDS (Nordblad et al., 2004), the study subjects represent well the various aspects of restorative treatment, especially for children. The results can thus be generalized to represent the restorative treatment practices of the metropolitan PDS.

##### Data collection

The cross-sectional study design collected data on dentists' restorative practices using a pre-designed form that dentists completed during routine clinical work over a two-week fixed period. Each dentist provided information on a maximum of 25 restorations, allowing a balanced description of dentists' restorative practices; data from dentists placing more restorations was not given more weight than data from those placing less. A strength of this study type is obtaining information on thousands of restorations in a relatively short time and recruiting a large number of dentists and patients with a relatively small effort.

Aspects affecting restorative treatment are numerous and procedures e.g. among high-caries risk patients may differ from those among low-risk patients (Jokstad and Mjör, 1991). One of the weaknesses of sample 1 is that no information on patients' general behavior and oral health status was gathered, and therefore, their impacts on treatment selection cannot be estimated. Otherwise, although not being as reliable a method as direct observation, data collection via the forms filled out by dentists as part of their routine clinical work strengthens the validity of this method. However, despite the simple structure of the pre-designed form permitting selection from given (reason) alternatives, for some replacements data on reasons were missing, implying that this policy is not part of dentists' daily routines, as reasons for replacement are not recorded in patient charts.

## **Sample 2**

### **Subjects**

Study II evaluated replacement of restoration at another PDS unit in the metropolitan area. The data were collected from patient records of a randomly selected sample representing young adults attending PDS, the majority of whom continued to use subsidized dental care after passing the age entitled to free-of-charge care. The observation units were individual restorations; thus, this setting allowed evaluation of restoration longevity since the patient records supposedly contained the comprehensive history of target restorations, namely replacement of restorations.

### **Data collection**

This cross-sectional survey of replacement of restoration included data obtained from the individual paper records of the Vantaa PDS. All dentists participated in meetings held monthly during working hours. Keeping abreast of new PDS policies and instructions and continuing education lectures ensured that dentists had up-to-date knowledge. Recordings of target restorations were made at visits in which restorative treatment was carried out, thus being representative of real-life practice.

Dentists were unaware of the forthcoming evaluation of their work, which strengthens the reliability of data. However, a quality assessment study at Vantaa PDS has found some inadequacies in record-keeping practices (Helminen, 2000). In the present study, the specific reason for re-restoration was missing for 14% of replacements; the most common finding leading to a “missing” classification of reason was the handwritten note “to be replaced”, naturally better than no note at all. This phenomenon supports the view that recording of a reason for replacement is not part of dentists’ daily routines, as it ought to be. Well-structured dental records have been identified as reliable a source for evaluation of quality of care (Marshall, 1995).

This data set, in line with many previous studies, took an individual restoration as the observation unit. A study on the longevity of Class II amalgam restorations had an observation unit of either individual restoration or patient and found no differences in results (Jokstad and Mjör, 1991). The authors have noted, however, that patients’ caries risk should be at the same level through the sample, excluding extremely high- or low-risk patients. In the present study, patients were not selected by their caries risk: the sample covered all patients.

Regarding longevity, retrospective data collection consisted of a history of replaced restorations only. This approach is valid in a cross-sectional study design. Recordings of the ages of both failed and acceptable restorations not needing replacement have resulted in similar longevities, suggesting that in cross-sectional studies the age of failed restorations is a valid indicator of clinical performance (Jokstad et al., 1994). In addition, Mjör (2000a) concluded that “It is feasible that the age at failure is a measure of the longevity of restoration”. In the present study, however, some difficulties were encountered when gathering information on comprehensive history of replaced restorations; patient records cannot automatically track a patient when domicile is changed. However, the vast majority of restorations could be traced back to the initial

restoration, adding reliability to the figures. Likewise, a representative sample and a real-life practice setting strengthen the validity of this method.

### **Sample 3**

#### Subjects

Studies III and IV evaluated dentists' self-reported practices and perceptions regarding aspects of restorative treatment for adults on the basis of a nationwide sample of working-aged GDPs in the PDS and private sector. A large sample size was used that represented members of the Finnish Dental Association: 98% of Finnish dentists belong to this association. A postal questionnaire to a randomly selected sample of dentists has often resulted in a low response rate: 31% in Norway (Mjör et al., 1999) and a response rate similar to this study (57%) among Finnish private practitioners (Widström and Forss, 1994). However, a moderate response rate does not necessarily lead to biased results (McFarlane et al., 2007). Here, public sector dentists were slightly overrepresented, but otherwise the responding dentists had age and gender distributions similar to those in the dentist population overall. The restorative practices of nonresponders are likely similar to those of respondents since all target dentists were GDPs, specialized dentists being excluded, and restorative treatment accounted for half of dental procedures in adults in both the PDS and private sector (Läärä et al., 2000, Helminen, 2004a, 2004b). In addition, Finnish dentists typically have a uniform undergraduate education; their basic knowledge can therefore be assumed to be similar. The results of sample 3 can thus be considered to be representative of restorative treatment practices of GDPs in Finland.

#### Data collection

To examine dentists' practices and perceptions, a postal questionnaire was employed since it is quick, can reach a large sample of practicing dentists, and contains no observer variation. To increase validity of the data, the contents were pre-tested with PDS and private dentists, and some questions were revised to a shorter and more explicit form; a detailed cover letter accompanied the questionnaire. Moreover, a reminder was sent, increasing the reliability of the data. It can be argued, though, that the answers might not correspond to the real-life behavior of respondents. On the other hand, as early as in the late 1970s Milgrom (1978a) found that dentists' self-reported and actual clinical treatments were similar. However, a more recent study suggests that dentists' self-reported restorative treatment thresholds have no relationship to their actual plans based on bitewings (Kay et al., 1992). In general, questionnaire-based research is favorable in reflecting attitudes and overall treatment trends. Furthermore, focusing research on attitudes may help to ensure that dentists work rationally.

## **6.2 Results of the study**

### **6.2.1 Reasons for placement and replacement of restoration in PDS**

The principal reasons for restorative treatment in the PDS were primary caries and replacements. Further, primary caries was the reason for restoration more often than for replacement of restoration, in accordance with other surveys from Finland (Widström and Forss, 1994, Forss and Widström, 2001), Norway (Mjör et al., 1999), and Iceland (Mjör et al., 2002b), in which the age-range of patients was similar to that in the present study. Older patients received replacement of restorations more frequently than younger patients. This is consistent with results from Sweden (Mjör, 1997a, Sunnegårdh-Grönberg et al., 2009) and Finland (Forss and Widström, 2004); however, all subjects in those investigations were aged over 15 years. Reasons for placement of restoration seem to depend strongly on the age of the patient, with older people having had more time to receive previous restorative treatments that need maintenance. In the present study of young adults, patients who had already had many restorations also received many replacements. This is in line with a previous study of children aged 6-10 years; those who had received more restorations had more replacements of restorations (Soncini et al., 2007). Restorative treatment does not eliminate the underlying cause of caries (Elderton, 1996). Patients are accustomed to thinking that dentists will take care of their problems, and hence, feel no need to change their lifestyle. From the patient's point of view, regular visits to dentists are easily interpreted as improved oral health.

The results of this study indicate that secondary caries and fractures are the main reasons for replacement in permanent and primary teeth, in line with the literature (Mjör, 1997a, Burke et al., 1999, Mjör et al., 2000b, Forss and Widström, 2001, Tyas, 2005). Dental education within EU countries aims at standardizing teaching (Plasschaert et al., 2005). An interesting finding was that esthetics as a reason was uncommon. With the increasing demands of modern society, patients are becoming more aware of esthetic and environmental factors. Indeed, patients seem to value esthetics more than do dentists (Espelid et al., 2006) or may put emphasis on alleged differences in safety (Tobi et al., 1999). Several optional reasons may explain the infrequency of esthetic replacements observed here. Dentists may categorize esthetic reasons under secondary caries, especially in anterior teeth. On the other hand, in light of the number of missing reasons, recording esthetics as a reason may have been avoided. Taking care of patients must be done in mutual understanding (Ministry of Social Affairs and Health, 1992), but PDS dentists do not involve patients or their parents in material selection as often as do private dentists (Forss and Widström, 1996, Ylinen and Löfroth, 2002). In general, in the PDS, changing an otherwise well-functioning amalgam restoration into composite is only done for allergy-related reasons that have been confirmed by a physician. For adults, subsidized dental care in the PDS may be one reason not to insist on esthetic restorations; replacements for esthetic reasons, however, have not been an issue in the private sector either (Forss and Widström, 2004).

### **6.2.2 Material selection in PDS**

Finding of amalgam not being used for children at all is in line with an earlier national report covering PDS (Forss and Widström, 2003). The minor use of amalgam in Finland may be due to the following: from the 1990s onwards, PDS dentists received a supplementary fee for one-surface restoration of composite but not for amalgam. The supplementary fees are based on time spent per dental treatment item and presume that placement of composite takes longer than placement of amalgam. In addition, for environmental reasons in 1994, the Ministry of Social Affairs and Health recommended restricting the use of amalgam to those occasions where no other material option was possible. These two factors have undoubtedly influenced the use of amalgam in PDS; however, amalgam has not been abandoned entirely and remains a rare alternative for posterior restorations in adults. This phenomenon has been reported previously in the private sector (Forss and Widström, 2004). Recommendations of respective authorities have influenced material selection also in the opposite direction; in the UK, the NHS funding system previously precluded the use of posterior composites (Gilmour et al., 2007), the use of amalgam being more frequent there than in Finland. The findings of the present study reveal that the material used most frequently in Finland is composite. Consequently, this unquestionably means large restorations in molars, including stress-bearing surfaces. The theoretical cost calculations by Sjögren and Halling (2002b) have implied that composite is the most expensive direct restoration for a molar Class II cavity, explaining in part the continuous rise in dental expenditures.

### **6.2.3 Use of local anesthesia in restorative treatment**

The findings of this study give no support to the second hypothesis; patient age influences the use of local anesthesia. Former studies on these topics and dentist-related factors are sparse; the present result that one in two adults receive local anesthesia for restorative treatment is consistent with a previous questionnaire study (Moore et al., 1998b).

The surprising finding that local anesthesia was used less frequently in children than in adults is of concern. In restorative treatment, patients must choose between two discomforts: pain during drilling or injection pain. Today, there are effective substances for topical anesthesia prior to injection, and several behavioral approaches can reduce discomfort during administration of local anesthesia. Regardless of painless administration of local anesthesia, the result may be inadequate or misplaced (Meechan, 2005b), with pain ensuing. In addition, all pain-reducing procedures are time-consuming. In the PDS, where the schedule has become overly full with increasing numbers of adults requiring complicated treatments, it might be tempting for dentists to ignore children's pain control and start drilling without local anesthesia. Milgrom (1994) found that for children private sector dentists used local anesthesia more frequently than their colleagues in the public sector. Since in Finland most children are treated by the PDS, the PDS dentists' contribution to the child's experience is marked. Authors have previously suggested that dentists might not take a child's complaint of pain seriously (Murtomaa et al., 1996).

For dentists, treatment of preschool children may be one source of stress; one in three pediatric dentists in Israel have reported a feeling of aggression towards child patients (Peretz et al., 2003). Administration of local anesthesia is also stressful (Simon et al., 1994) and can affect the restorative treatment provided to young children (Splieth et al., 2008). The majority of children and adolescents visit a PDS dentist in the absence of their parents, and in general, adults have a higher authority to demand local anesthesia. However, in Denmark, 80% of dentists reported never compromising on painless treatment of children (Rasmussen et al., 2005). On the other hand, dentists may perceive cavities in primary teeth to be less invasive than in permanent teeth, and further, for small children applying an atraumatic restorative treatment (ART) method means excavation with a hand instrument instead of using a steel bur, and local anesthesia is not necessarily needed (Schriks and van Amerongen, 2003). Whatever the case, numerous unsuccessful dental visits due to an uncooperative child is a common reason for treatment with general anesthesia (GA) in the PDS (Savanheimo and Vehkalahti, 2008), affecting the cost of treatment and including risks of GA, which surely exceed the risks of local anesthesia. Moreover, research on pain experiences in the brain suggests a pathway to pain learning (Fitzgerald, 2005); therefore, successful pain management in all dental care should be seen as preventing the development of a chronic pain condition. The present results substantiate the need for further studies on dentists' attitudes and behavior towards children's pain control during restorative treatment.

Walls et al. (1985) have previously reported that use of local anesthesia improved restoration longevity. However, here, the use of local anesthesia seemed to have a negative impact on the longevity of posterior amalgam restorations in the PDS in 1994-1996; mean longevity was higher without the use of local anesthesia. This might be explained by local anesthesia probably being used only in more demanding cases, such as larger restoration on a child with behavioral problems, therefore the environment for placement of restoration was not adequate despite the local anesthesia. One must bear in mind that in this sample of young adults the highest longevity was achieved when the patient age was under 15 years at the time of initial restoration. Assessment of restoration longevity would benefit from further studies on the influence of the use of local anesthesia, considering that even a minor increase in longevity clearly reduces costs of treatment.

#### **6.2.4 Restoration longevity in real life and dentists' perceptions**

Longevity of posterior amalgam restoration (mean ca. nine years) in young adults in this study has fallen between 7 (Rytömaa et al., 1984) and 12 years (Forss and Widström, 2001) previously reported in Finland. The longevity findings in the present study are, however, partly underestimated since for 21% of restorations the date of initial restoration was approximated and the observation period thus truncated. Interestingly, for amalgam, there is no difference in the median longevity between replaced restorations in first and in second molars, but amalgam longevity in premolars is shorter than in molars. This latter finding contradicts with earlier findings (Kreulen et al., 1998, Janus et al., 2006). The present study sample comprised young adults, and therefore, maximum longevity for



restorations in premolars and second molars cannot reach the same level as for restorations in first molars placed at a younger age (Burke et al., 2001). In this study, caries on another surface (reason for 26% of replacements) is an alternative explanation. Longevity of amalgam Class I restoration was greater than that of Class II restoration, in line with other studies (Friedl et al., 1994, Jokstad et al., 1994, Kreulen et al., 1998, Bernardo et al., 2007). The mean longevity of posterior composites (around two years) here should be interpreted with caution. In the mid-1990s these materials and techniques were new, and the number of observed restorations was low. By contrast, for young adults, the posterior amalgam longevity in the present study represents an appropriate quality of care. Since posterior composites dominate today, their longevity warrants further investigations.

The present results show that the overall replacement rate of posterior restorations among young adults was 7%. The rate is lower than in an epidemiological survey, where 23% of restorations were assessed as needing replacement among 600 adults aged 20-44 years in the Netherlands (Kroeze et al., 1990) or in a study with 10% of amalgam restorations in molars needing replacement among university students in Finland (Rytömaa et al., 1984). Nevertheless, an even lower replacement rate of 3% was reported for 8310 restorations in 383 regular attenders in a Scandinavian survey (Jokstad et al., 1994). Thus, the replacement rate in the present study of young adults can be considered to represent a relatively good quality of care in the PDS.

Regarding dentists' perceived estimates of restoration longevity, the results exceed the median longevity reported in recent studies by 3 years for composite and by 4-10 years for amalgam. Dentists were asked to estimate longevity in general, but instead they might have given estimates of ideal longevity. In USA, an ideal longevity estimate for one to three surface amalgam restorations was 17 years compared with 11 years for average longevity (Maryniuk and Kaplan, 1986). The same study also reported that specialized dentists gave lower restoration longevity estimates. In the present study respondents were GDPs only, providing a potential explanation for the optimistic estimates of longevity. A need exists for delivering a more realistic picture of longevity either by reliable clinical prospective studies or by continuing education.

### **6.2.5 Dentist-related factors and restorative treatment practices**

The findings of this study regarding restorative treatment practices showed great variation by dentist's age and small variation by gender, thus giving only minor support to the hypothesis of dentist-related factors having no impact on variation in reasons for placement and replacement or on use of local anesthetics. By contrast, the results concerning material selection strongly supported this hypothesis.

Results from Norway (Mjör et al., 2000b) suggested that females are stricter in their criteria of failed restorations. By contrast, in the present study, male dentists more frequently diagnosed secondary caries than female dentists. The replacement rate was, however, higher among female dentists. These gender differences lack reasonable explanations, warranting future investigations.

Younger dentists, more often than older ones, cited secondary caries as the reason for replacement. This is in line with findings from Norway; the authors offered the explanation that differentiation between secondary caries and staining would improve due to increased clinical knowledge among more experienced dentists (Mjör et al., 2000b). Secondary caries is an ill-defined entity that is difficult to diagnose clinically (Söderholm et al., 1989), and in reality primary caries in the vicinity of the restoration margin should serve as the definition (Mjör and Toffenetti, 2000). As long as no accurate and totally reliable method for caries diagnosis exists, dentists must rely on the clinical view, possible radiographs, previous knowledge, and clinical experience; within these uncertainties, experience is a valuable asset when deciding whether to drill or to “wait and see”. Further, “routines are easier to deal with than probabilistic decision-making” (Maryniuk, 1990). PDS has not implemented recommendations for precise uniform restorative diagnoses, and therefore, dentists' treatment practices probably follow those adapted during education. In Australia, dentists' responses to treatment plans remained stable from 1997-1998 to 2004, suggesting that if routines are established they develop before or soon after graduation (Brennan and Spencer, 2006). In addition, the present finding that more experience results in fewer replacements is supported by the results of others (Söderholm et al., 1989, Coppola et al., 2003). It is tempting to suggest that younger dentists perceive old restorations as not being “perfect” and see someone else's “handwriting”. Nevertheless, this is not supported by an old study that reported dentists' self-assessment of restorations as more critical than determined via peer review (Milgrom et al., 1978b). Possible changes due to aging of dentists' skills and restorative treatment practices are a future challenge for research.

Regarding composites, both posterior and anterior, dentists' self-perceived longevity estimates were longer in the private sector than in the public sector. Cross-sectional studies from Norway (Mjör et al., 2000a) and the UK (Burke et al., 2002) have revealed shorter restoration longevity in the public sector. In Finland, patients in the private sector have different characteristics from patients attending PDS. Mostly women and patients belonging to the high-income group use private sector services (Arinen et al., 1998). High educational level, which usually relates to higher socioeconomic status, along with female gender have both been associated with more sound teeth and less caries than in the other education brackets or male gender (Kelly et al., 2000, Suominen-Taipale et al., 2008), thus leading to higher restoration longevity. Differences between dentists regarding replacement criteria can be due to variation in patient factors such as caries activity (Jokstad and Mjör, 1991). Private dentists may be more self-confident, the majority having regularly returning patients. By contrast, PDS dentists have more irregular patients and fewer possibilities of choosing their patients. Moreover, differences in restoration longevities in real life may also be related to the dentists' payment system, as stated by Dawson and Smales (1992). Their study in Australia retrospectively followed a total of 1918 restorations in Army patients for up to 16 years and concluded that salaried Army dentists achieved a higher restoration longevity than reported earlier for private practitioners.

## 7 CONCLUSION AND RECOMMENDATIONS

Restorative treatment practices in Finland are similar to those in other Nordic countries. The results of the present study confirm primary caries and replacement of restorations as the major reasons for restorative treatment in the metropolitan PDS. Secondary caries and fractures predominate as reasons for replacement of restoration for all materials of replaced restorations. Material selection favors direct tooth-colored materials, but use of amalgam has not been completely abandoned. Dentist-related factors have an impact on variation in reasons given for placement and replacement of restoration and use of local anesthesia, giving no support to the working hypothesis. Regarding Finnish dentists' views and perceptions, their estimates of restoration longevity were very optimistic and exceeded the median longevity reported in recent studies by 3 years for composite and by 4-10 years for amalgam. Self-reported use of local anesthesia was more frequent among public sector dentists than among their private sector peers.

1. The use of local anesthesia should be emphasized in restorative treatment, especially for children.
2. Routine recording of the reason for placement and replacement of restoration should be encouraged; such a practice might result in improved dentists' self-assessment of diagnostic skills. In addition, during regular working hour meetings, dentists in the PDS should together discuss clinical cases and their treatment options, thus helping to standardize dentists' restorative treatment practices. For private solo-practitioners, a similar discussion could be organized via the internet by the Finnish Medical Network (FiMnet) supported by the Finnish Dental Association.
3. Dentists should be able to adapt new concepts and change their treatment practices when needed. For quality assessment of their own work, comprehensive use of computers and of course suitable software could be beneficial in revealing e.g. dentists' distribution of their treatment diagnoses and in calculating mean restoration longevity.

## 8 SUMMARY

Restorative treatment accounts for a substantial part of general dental practitioners' workload. Esthetic demands of modern society, erosion due to new dietary habits, and abrasion due to stressful work, not to mention prior restorations needing maintenance in the growing number of the elderly can all benefit from dental restorations despite the modern methods that interfere with the caries process and caries decline trend.

The aim of this study was to elucidate restorative treatment practices in real life and dentists' views and perceptions of these practices. Further, this study aimed at assessing variation in dentist-related factors in relation to aspects of restorative treatment practices. The working hypotheses were that dentist-related factors do not have an impact on variation in reasons for placement and replacement practices, material selection, or use of local anesthesia. Further, the use of local anesthesia does not vary according to patient age.

Reasons for placement and replacement of restoration, material selection, posterior restoration longevity, and use of local anesthesia were assessed with two cross-sectional data sets from the Public Dental Service (PDS) in 1994-1996 and 2001 in the metropolitan area. In addition, dentists' self-reported use of local anesthesia and estimates of restoration longevity were investigated by means of a nationwide questionnaire in 2004. All three data sets covered some dentists' background information, including gender, year of birth or graduation, and working sector.

Primary caries and replacement of restorations were major reasons for placement of restoration in the PDS in 2001. Primary caries was the predominant reason in children, and replacements the main reason in adults. Secondary caries and fractures dominated as reasons for replacement of restoration similarly for all replaced restoration materials. Of all new restorations in the PDS in 2001, the clear majority (69%) were composites, 21% were glass-ionomer and its derivatives, and 5% were amalgam. Amalgam was not used at all for children aged under 13 years.

Restoration longevity in real life in the PDS in 1994-1996 showed that the mean age of replaced posterior restoration was 8.9 (SD 5.2) years for amalgam and 2.4 (SD 1.4) years for tooth-colored restorations. According to the category of replaced amalgam restoration, mean longevity was higher for Class I than for Class II or MOD. In addition, the mean longevity for amalgam restoration was higher when the patient was aged under 15 years at the time of initial restoration. The number of patients' previous posterior restorations had an impact on the number of posterior replacements, the actual replacement rate for all existing posterior restorations being 7%. Dentists' self-reported estimates of restoration longevity were optimistic in 2004: the mean longevity was 18.8 (SD 7.3) years for amalgam and 9.0 (SD 3.6) years for posterior composite.

The working hypothesis was not supported regarding dentist-related factors' impact on variation in reasons for placement, replacement, or use of local anesthesia. In the PDS in 2001, replacements of restorations were made by younger dentists more frequently than by older dentists. Younger dentists more often used local anesthesia for primary restoration than older dentists, especially in primary teeth. In 1994-1996, the replacement rate of posterior restorations in the PDS was greater among female dentists than among male dentists, especially for amalgam. Working sector had an impact on dentists' self-reported

use of local anesthesia and estimates of restoration longevity; public sector dentists reported using local anesthesia more frequently than private sector dentists for Class II and Class III restorations. Private sector dentists had longer estimates of posterior composite longevity than public sector dentists.

Local anesthesia was used in half of all cases and more frequently for older patients (55%) than for patients aged under 13 years (35%) in the PDS in 2001, thus giving no support to the second working hypothesis.

The results regarding restorative practices and use of local anesthesia are in line with previous research. Primary caries and replacement of restorations were the major reasons for restorative treatment. Variation exists in reasons for placement and replacement of restorations and in the use of local anesthesia according to dentist-related factors.

## 9 TIIVISTELMÄ

Paikkaushoito muodostaa merkittävän osan hammaslääkärien työstä. Vaikka karieksen esiintyvyys on vähentynyt voimakkaasti ja sen hallinnassa käytetään nykyaikaisia menetelmiä, silti paikkaushoitoa tarvitaan edelleen täyttämään nyky-yhteiskunnan asettamia esteettisiä haasteita, korjaamaan uusien ruokailutottumusten ja työstressin aiheuttamia eroosio- ja abraasiovauriota, puhumattakaan kasvavan vanhenevan hampaallisen väestön aiempien paikkojen vaatimasta ylläpitoahoidosta.

Tämän tutkimuksen tavoitteena oli tutkia paikkaushoidon käytänteitä hammaslääkärien potilastyössä sekä hammaslääkärien omia käsityksiä niistä. Lisäksi tutkimuksen tarkoituksena oli arvioida paikkaushoitokäytänteiden vaihtelua hammaslääkärien taustatekijöiden mukaan. Työhypoteeseinä oletettiin, että paikkaussyyt, paikkojen uusimissyyt, materiaalivalinnat ja puudutuksen käyttö eivät riipu hammaslääkärien taustatekijöistä, eikä puudutuksen käyttö paikkaushoidossa riipu potilaan iästä.

Paikkausta ja paikkojen uusimisen syitä, materiaalivalintoja, takahammaspaikkojen kestoa ja puudutuksen käyttöä tutkittiin terveystieteiden tutkimuskeskuksessa kahden poikittaisaineiston pohjalta vuosina 1994-1996 ja 2001 pääkaupunkiseudulla. Lisäksi koko maan kattavalla kyselytutkimuksella vuonna 2004 selvitettiin hammaslääkärien käsityksiä paikkojen kestosta yleensä sekä näkemyksiä puuduttamisesta aikuisten paikkaushoidon yhteydessä. Kaikki kolme aineistoa sisälsivät hammaslääkärien taustatietoja kuten ikä, valmistumisvuosi ja työskentelysektori.

Terveystieteiden tutkimuskeskuksessa vuonna 2001 pääasialliset syyt paikkaushoitoon olivat primaarikaries ja uusintapaikkaukset. Lapsilla syynä oli yleisimmin primaarikaries ja aikuisilla paikan uusiminen. Paikkojen yleisimmät uusimissyyt olivat sekundaarikaries ja lohkeamat kaikilla materiaaleilla. Vuonna 2001 valtaosa terveystieteiden tutkimuskeskuksessa tehdyistä paikoista oli yhdistelmämuoveja (69%), 21% oli lasi-ionomeereja tai kompomeereja, ja 5% oli amalgaamia. Alle 13-vuotialla amalgaamia ei käytetty lainkaan.

Terveystieteiden tutkimuskeskuksessa vuosina 1994-1996 uusintapaikkaukseen päätyneiden takahammaspaikkojen keski-ikä oli 8.9 (SD 5.2) vuotta amalgaamille ja 2.4 (SD 1.4) vuotta hampaanvärisele paikalle. Takahammaspaikan keski-ikä oli korkeampi I luokan amalgaameilla verrattuna II luokan ja MOD paikkojen keski-ikään. Lisäksi, jos hammas oli alunperin paikattu potilaan ollessa alle 15-vuotias, niin takahampaan amalgaamipaikan keski-ikä oli korkeampi kuin jos hammas oli paikattu potilaan ollessa yli 15-vuotias. Aiempien paikkojen lukumäärä vaikutti potilaalle tehtyjen uusintapaikkausten määrään; takahammaspaikkojen uusimissuhde oli 7%. Hammaslääkärien omat arviot paikkojen kestosta olivat optimistisia vuonna 2004: amalgaamipaikan arvioitu keski-ikä oli 18.8 (SD 7.3) vuotta ja 9.0 (SD 3.6) vuotta yhdistelmämuoville.

Vastoin työhypoteesiä paikkaus- ja uusimissyyt sekä puudutuksen käyttö vaihtelivat hammaslääkärien taustatekijöiden mukaan terveystieteiden tutkimuskeskuksessa vuonna 2001. Primaaripaikkauksissa nuoremmat hammaslääkärit käyttivät puudutusta useammin, erityisesti lapsille, verrattuna vanhempiin hammaslääkäreihin. Vuosien 1994-1996 terveystieteiden tutkimuskeskuksessa aineiston perusteella naishammaslääkärit olivat uusineet takahammaspaikkoja useammin kuin mieshammaslääkärit. Erityisen selvänä tämä ero näkyi amalgaamipaikkojen uusimisessa. Työskentelysektori vaikutti hammaslääkärien

omiin näkemyksiin puudutuksen käytöstä aikuisilla ja arvioihin paikkojen kestosta: II ja III luokan paikkojen yhteydessä terveystakeskushammaslääkärit ilmoittivat käyttävänsä puudutusta useammin kuin yksityishammaslääkärit. Nämä taas arvioivat yhdistelmämuovipaikkojen keston pidemmäksi kuin kollegat terveystakeskuksessa.

Terveystakeskushammashoidossa vuonna 2001 paikallispuudutusta käytettiin joka toisen paikkauksen yhteydessä, ja useammin aikuisten (55%) kuin alle 13-vuotiaiden (35%) paikkaushoidossa.

Nyt esitetyt havainnot paikkaushoitokäytänteistä ja puudutuksen käytöstä ovat yhteneväisiä aiempien tutkimustulosten kanssa. Pääsyyt terveystakeskuksen paikkaushoittoon ovat tämän tutkimuksen perusteella primaarikaries ja uusintapaikkaukset. Paikkaus- ja uusimissyyt sekä puudutuksen käyttö vaihtelevat hammaslääkärin taustatekijöiden mukaan.

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